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A GUIDE TO THE STUDY

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Elementary Physics, Elementary Chemistry

AND

Physical Geography

FOR THE USE OF CANDIDATES PREPARING FOR THE

MATRICULATION, SCHOOL FINAL

AND

ENTRANCE EXAMINATIONS

Containing over 600 questions (including those set at former University examinations in the Universities of Madras, the Punjab, Cambridge, London, etc.) with full answers illustrated by 143 figures, and over 700 questions without answers.

BY

K. SITARAMAIYA, B.A., L.T.

(The Madras Christian College.)

SECOND EDITION.

1905.

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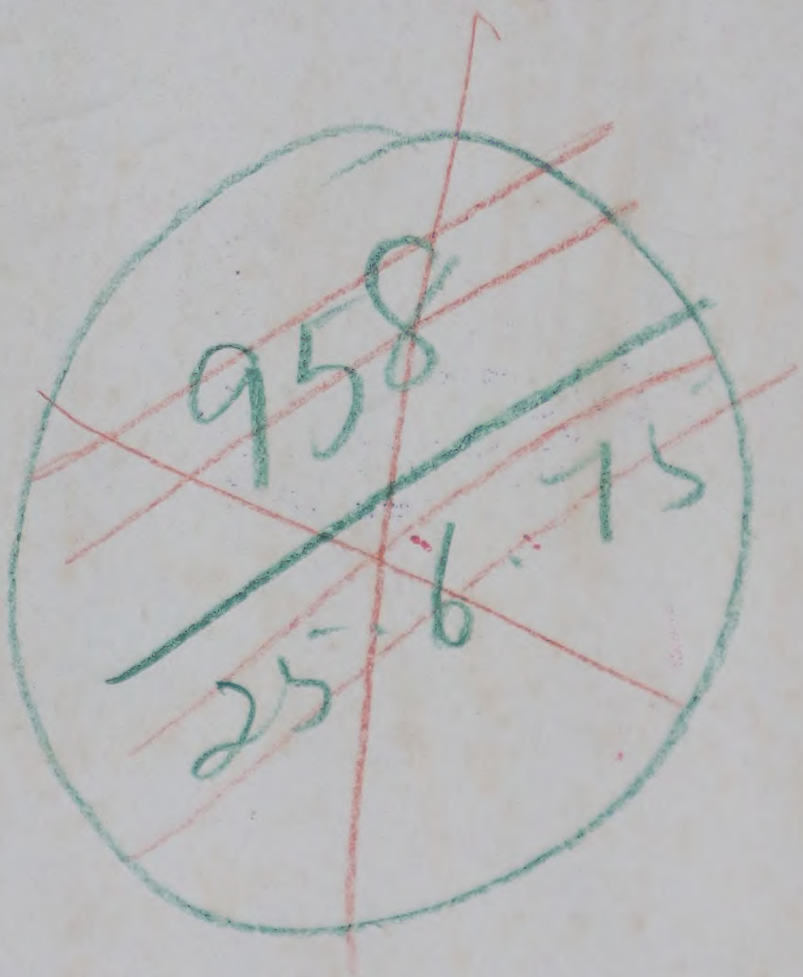

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PREFACE TO THE SECOND EDITION.

NUMEROUS improvements have been made in this edition. A third part, containing a large number of questions on Physical Geography, with full answers, illustrated by numerous figures, has been added. Questions from the Punjab University papers having been incorporated, the number of questions on Physics and Chemistry has also been largely increased, and the book has been brought up to date.

I desire to acknowledge my indebtedness to Professors Blanford, Thornton, Geike, etc., from whose works I received valuable help in the preparation of the third part of this book.

MADRAS,
August, 1905. } K. S. R.

EXTRACT FROM THE PREFACE TO THE FIRST EDITION.

THIS book contains a large number of questions with full answers illustrated by figures, and also numerous questions without answers. These are all arranged according to their subject-matter. As the object of this publication is to give the candidate an idea of the answers required from him, he must read the answers given carefully and then proceed to answer the (unanswered) questions at the end of every section.

* * * *

Candidates cannot be considered to have taken the fullest advantage of this publication if they have not done as suggested.

MADRAS,
August 1904. } K. S. R.

CONTENTS.

PART I.—PHYSICS.

Questions 1—794.

Section.		*Page.*
I.	Matter and Natural Forces	1
	Questions for Exercise	20
II.	Solids, Liquids and Gases	22
	Questions for Exercise	59
III.	Energy and Sound	71
	Questions for Exercise	89
IV.	Heat	94
	Questions for Exercise	135
V.	Light and Electricity	144
	Questions for Exercise	203—212

PART II.—CHEMISTRY.

Questions 795—1109.

I.	Elements, Compounds, etc.	1
II.	Non-Metals	24
III.	Metals	41
IV.	General	52
V.	Chemical Laws	27
VI.	Chemical Arithmetic	75
	Questions for Exercise	87—106

PART III.—PHYSICAL GEOGRAPHY.

Questions 1110—1310.

I.	The Earth	1
II.	The Land	10
III.	The Sea	21
IV.	Atmosphere	27
V.	Climate, People, etc.	31
VI.	General	42
	Questions for Exercise	53—61

PHYSICS.

SECTION I.

MATTER AND NATURAL FORCES.

Q. 1.—Compare the velocity of sound and the velocity of light with that of an express train going at 60 miles an hour.—M.U. 1904.

Ans.—Velocity of sound = 1,100 ft. per second.

Do. of light = 186,000 miles per second.

Do. of train $= \frac{60 \times 1.760 \times 3}{60 \times 60} = 88$ ft. per second.

$\therefore$ Velocity of sound : Velocity of train : : 1,100 : 88.

Velocity of light : Velocity of train : : 186.000 × 1,760 × 3 : 88.

$\therefore$ Velocity of S. : Velocity of T. : : 25 : 2.
Velocity of L. : Velocity of T. : : 11,160,000 : 1. } **Ans.**

Q. 2. (1) What is the British System of Units for measurement? (2) How does it differ from the French System? (3) By what other name is the French System known?

Ans. -(1) In the British System '*pound*' is the unit of weight; '*yard*' is the unit of length; and '*gallon*' is the unit of capacity. [**Scientific units:** *foot* for length, *second* for time and *pound* for mass.]

(2) In the French System, *meter* is the unit of length; *gram* is the unit of weight (mass); and *liter* is the unit of capacity.

(3) The French System is also known as the 'Metric System.'

☞ *Abbreviations:*— M. U. for Madras Matric.; L. U. for London Matric.; B. U., Bombay University; Cal. U., Calcutta University; All. U., Allahabad University; Pun. Ent., Punjab Entrance.

Q. 3.—State the measures of the 'Metric System' and compare them with those of the British System.

Ans.—

Length—

10 Millimeters	= 1 Centimeter.	10 Decameters	= 1 Hectometer.
10 Centimeters	= 1 Decimeter.	10 Hectometers	= 1 Kilometer.
10 Decimeters	= 1 Meter.	10 Kilometers	= 1 Myriometer.
10 Meters	= 1 Decameter.		

[1 Meter = 39·4 inches; 1 Myriometer = 6·2 miles; 1 Inch = 2·5 Centimeters; 1 Yard = 0·9 Meters; 1 Mile = 1·6 Kilometers.]

Capacity—

10 Milliliters	= 1 Centiliter.	10 Decaliters	= 1 Hectoliter.
10 Centiliters	= 1 Deciliter.	10 Hectoliters	= 1 Kiloliter.
10 Deciliters	= 1 Liter.	10 Kiloliters.	= 1 Myrioliter.
10 Liters	= 1 Decaliter.		

[1 Milliliter, *i.e.*, one Cubic Centimeter = ·06 Cubic Inch; 1 liter = ·03 Cubic Foot; 1 Cubic Inch = 16·4 Cubic Centimeters; 1 Gallon or 277·3 Cubic Inches = 4·5 liters.]

Weight—

10 Milligrams	= 1 Centigram.	10 Decagrams	= 1 Hectogram.
10 Centigrams	= 1 Decigram.	10 Hectograms	= 1 Kilogram.
10 Decigrams	= 1 Gram.	10 Kilograms	= 1 Myriogram.
10 Grams	= 1 Decagram.		

[1 Gram = 15·4 Grains; 1 Kilogram = 2·2 lbs.; 1 lb. Avor. = 4 Kilograms; 1 Cwt. = 50·8 Kilograms.]

Q. 4.—What is the 'C.G.S.' system of Units and where is it used?

Ans.—The C.G.S. system of Units is the system which has centimeter for the unit of length, gram for the unit of mass, and second for the unit of time. This system is at present used in scientific calculations all over the world.

["For the convenience of scientific men of all nations, C.G.S. system of Units has been universally adopted. A committee of the British Association, specially appointed to recommend a system of units for general adoption in scientific calculation, have recommended the adoption of the *centimeter* as the unit of length, the *gram* as the unit of mass, and the *second* as the unit of time."]

Q. 5.—Explain the term 'Velocity.' If a person walk towards the prow or stern of a steamer in motion, he has at the same time two velocities. Name them.

Ans.—Velocity is the rate with which a body moves. "The velocity of a moving body is thirty feet per second" means that the body passes over a space of thirty feet per every second of time.

The *two velocities* of the man are:—(1) The velocity of his own motion, and (2) the velocity of the steamer.

Q. 6.—Define volume, mass, weight and density. Compare the mass, weight and density of equal volumes of water at 4°C. and 40°C.—M.U. 1877.

Ans.—'*Volume*' means the size or bulk of a body, and depends upon the space occupied by the body.

'*Mass*' denotes the quantity of matter contained in a body.

'*Weight*' is the name given to the amount of force exerted by gravity on the matter contained in a body. When we support a body and thus prevent it from falling down to the earth, we resist the action of gravity on the body and then we feel its weight.

'*Density*' denotes the closeness with which the particles of a body remain together.

A certain volume of water at 4°C. is heavier and denser than an equal volume of water at 40°C. Because, *heat* expands bodies and a body in an expanded state is lighter than the body that has not expanded, bulk for bulk.

When a body expands the same mass occupies a larger volume. Hence in a given volume there will be less matter than before. A given volume of water at 4° C, therefore, possesses greater mass than the same volume of water at 40°C.

Q. 7.—Name the several natural forces which are brought into action in the following operations:—(i) Lighting a fire. (ii) Building a mud wall. (iii) Using your blotting paper. (iv) Climbing a toddy tree.—M.U. 1878.

Ans. (i) Chemical Action. (iii) Capillary Force.
(ii) Cohesion; Adhesion. (iv) Gravity and Friction.

Q. 8.—Can a body have *more than one* centre of gravity? If I fix two similar balls at the end of a knitting wire, does the whole have one or more than one centre of gravity?

Ans.—So long as the body remains as *one whole*, it cannot have more than one centre of gravity. By its very nature, the point is such that when supported, the whole body is kept at rest in any position. A single body cannot have two or more such points.

In the given case, although the balls are two in number, both make up a single body, being connected by the wire. The whole system will, therefore, have only one centre of gravity, and this will be near the middle of the wire.

Q. 9.—When the arm, which is quickly raising a tin pan containing peas, is suddenly brought to a stop, the peas in the pan fly up, fall down, and are scattered on the floor. State and explain the property of matter which this illustrates.

Ans.—The property of matter illustrated here is 'Inertia'. Inertia is that property of *matter* on account of which a body cannot change its state by itself, whether that state be one of rest or of motion. In the instance mentioned the peas in the pan were moving with it. The pan was stopped, for the hand raising it was stopped. The peas were not stopped. They continued their upward motion. So they flew into the air. Then, having had no support, they fell to the ground.

Q. 10.—Explain the term 'Force'. Describe experiments to show (i) that it needs force to stop a moving body and (ii) that it needs force to start a body at rest.—M.U. 1889.

Ans.—Force is that which changes or tends to change the state of a body whether that state be one of rest or of motion; it is also that which changes the direction in which a body moves and increases or decreases its rate of motion.

Experiment for (i).—Take a tin pan with some peas in it. Quickly raise the pan. Now the peas as well as the pan move. Bring the pan to rest suddenly. The peas continue their motion and will jump up. This is because there was nothing to stop the motion of the peas. Thus we learn that force is necessary to stop a moving body.

Experiment for (ii).—Hold a tin pan containing peas in it. Now both the pan and the peas are at rest. Suddenly and quickly bring the pan down. The peas do not follow the motion of the pan and, so, remain behind and fall to the ground; for there was nothing to make the peas move. **This shows that force is necessary to start a body at rest.**

Q. 11.—Explain what happens when a card is placed on a tumbler with a small coin in the middle of it and the card is given a quick sharp tap at a corner as in Fig. 1.

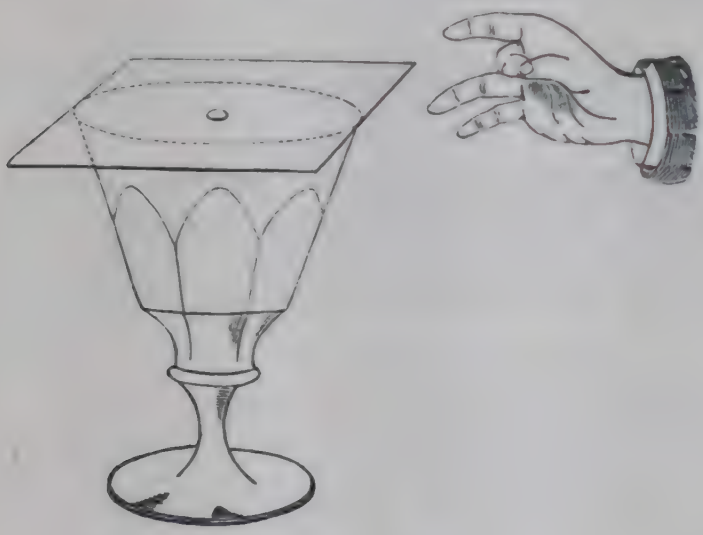

Fig. 1.

Ans.—The card flies off and the coin falls into the tumbler. The reason is this. When both the card and the coin are at rest, a sharp tap is given to the card. This makes the card move, but the coin remains in a state of rest, because there is nothing to change its state; and it cannot change its state of itself. The coin is, therefore, left behind without any support, and falls into the tumbler. The property of matter illustrated here is 'Inertia.'

[*In answering questions of this kind, first of all state what happens, and then give the reason for that.*]

Q. 12.—Explain the terms matter, motion, velocity, acceleration, retardation, uniform acceleration.

Ans.—Matter is anything which occupies space exclusively, offers resistance, possesses weight and transfers motion to other things when striking against them.

Motion means change of place.

Velocity means the rate with which a body moves.

Acceleration means the increase in the velocity of a body.

Retardation means the decrease in the velocity of a body.

Uniform acceleration is the increase in the velocity of a body which takes place regularly at equal intervals of time.

Q. 13.—Explain what property of matter makes it possess weight.

Ans.—'*Matter can be acted on by force.*' Gravity is the name given to the force which the earth exerts to pull all things to itself. The effect of this force on bodies is felt as their weight when those bodies are prevented from falling to the earth. If there were no gravity, there would be no weight.

Q. 14. When a marble is rolled along a table, its particles are at the same instant under the action of several physical forces. Name four of these, and say, in a few words, how each acts. M.U., 1881.

Ans.—1. Gravity : 2. Cohesion : 3. Friction : 4. Resistance of the table.

(*a*) *Gravity* is the force exerted by the earth on other bodies. This force is exerted from the centre of the earth. The marble is, therefore, attracted by the earth towards itself.

(*b*) *Cohesion* is the force which binds together the particles of a body and keeps them together. This force acts on the particles of the marble and keeps them together in the form of a whole marble.

(*c*) *Friction* is the name given to the resistance offered to a moving body by the surface on which the body moves. Here the surface of the table offers resistance to the motion of the marble over it.

(*d*) The resistance of the table prevents the marble from falling to the earth.

Q. 15.—Name three of the chief forces of nature. How do they differ from one another?—M.U., 1885.

Ans.—

Forces.	How they differ from one another.
1. Capillary Force ...	(1) This acts only between liquids and solids. (2) Only when they come into contact with each other. (3) The liquid either rises above, or sinks below, its level.
2. Chemical Force ...	(1) This acts only between the particles of dissimilar substances. (2) Only when they are intimately mixed. (3) The resulting substance is entirely different from the original substances between which it acts. (4) In the course of its action heat and, sometimes, light are produced.
3. Cohesion ...	(1) This force acts between the particles of same body. (2) When the particles are extremely near. (3) No new substance is produced.

Q. 16.—What are the five senses? Why have they been called the gateways of knowledge?

Ans.—The senses are five in number, namely, the sense of touch, the sense of taste, the sense of sight, the sense of hearing and the sense of smell. These senses help us in acquiring a knowledge of the things around us; that a wall is white, we learn with the help of our sense of sight; that sugar is sweet, we learn with the help of our sense of taste; and so on. For this reason the senses have been called 'Gateways of knowledge'.

Q. 17. What is a property of matter? Explain the difference between the two classes into which properties of matter have been divided, and give two examples of each.

Ans.—By a property of matter is meant the way in which matter presents itself to our *senses*.

Properties of matter have been divided into 'General Properties' and 'Special Properties.' General properties are those that are possessed by all kinds of matter; while special properties are those that are possessed only by some kinds of matter and not by all. Inertia and Indestructibility are two of the properties possessed by all kinds of matter. These are, therefore, called 'General properties.' Solidity and liquidity are properties which are possessed only by some, but not by all. kinds of matter. These are, therefore, called 'Special properties.'

Q. 18.—Explain what happens to the rider when a galloping horse suddenly stops.

Ans.—The rider is thrown forwards on the head of the animal. The reason is this. Before the horse has stopped, both the horse and the rider were in motion. When the horse stops, only the lower part of the rider that is in contact with the back of the horse comes to rest. The upper part of the man continues its motion as there has been nothing to stop it, and as bodies cannot change their state by themselves on account of *inertia*. As the lower part of the rider comes to a stop while the upper part continues to move, the rider is thrown forwards on the head of the animal.

Q. 19.—Explain what happens to a person sitting in a train, when the train starts suddenly.

Ans.—The person feels a jerk *in the direction opposite to that* in which the train moves. The reason is this. Before the starting of the train both the person and the train were at rest. When the train moves suddenly that part of the man in contact with the train, namely, the lower part, moves with the train, while the upper part of the man remains in the same state and place as before. There is nothing to change the state of the upper part of the man, and, on account of *inertia*, it cannot change its state by itself. The lower part moving, and the upper part remaining as before, the result is a jerk to the man in the direction opposite to the motion of the train.

Q. 20. How can you determine the exact direction in which gravity acts? If this direction be determined at different places on the earth's surface, will the lines be found parallel to each other?—M.U., 1883.

Ans.—I can determine the exact direction by suspending a heavy body, a piece of lead or stone, by means of a thread: because if a body be suspended by a string, the string hangs in the direction in which the body

would fall if allowed to do so. This is the direction along which the force of gravity acts. The line drawn in the prolongation of the string passes through the centre of gravity of the body towards the centre of the earth. The lines referred to will all pass through the centre of the earth. Hence they will not be parallel. If, however, the places selected are very near those lines may practically be considered parallel, because when produced they meet only at a considerable distance, namely, the centre of the earth.

Q. 21.—(*a*) "Suppose you could annihilate the interior of the earth (preserving its crust to stand on), would there be any alteration in the weight of a lump of lead? (*b*) Suppose you could hold a pound of lead in your hand in the middle of empty space without the earth being under you, would the lead have weight?"

Ans.—(*a*) Yes. The lump of lead would weigh very much less than before. The weight of a body is due to the force of *gravity* acting on it. This force is exerted by the earth on account of the enormous matter which it contains. If this matter were diminished, the force of gravity also would correspondingly decrease, and hence the weight of a body suffers.

(*b*) In this case the lead would have no weight whatever due to the earth. In the former case it might possess a little weight owing to the crust. But in this case the weight disappears altogether.

Q. 22.—What is the difference between 'Gravity' and the 'Centre of gravity of a body'?

Ans.—Gravity is a force. It is the force exerted by the earth to attract things to itself. *Centre of gravity* is the name given to that point with reference to a body which, when supported, keeps the whole body at rest *in any position*. Therefore, *gravity* is a force and is exerted by the earth alone; *centre of gravity* is a particular point and is possessed by all bodies.

Q. 23.—State the peculiarity about the 'centre of gravity' of a body. How would you determine the centre of gravity of a body?

Ans.—*An important property of 'centre of gravity' is this*: The centre of gravity of a body always tends to occupy the lowest possible position. Because the earth attracts other bodies towards its centre. This

attraction of the earth upon a body is, as it were, concentrated at the centre of gravity of the body. The centre of gravity of a body tries to be as near to the centre of the earth as possible.

How to determine the centre of gravity of a body :—First, suspend the body freely in any position by a thread. Since the body is freely suspended, its centre of gravity will be somewhere in the line drawn in prolongation of the thread, because the centre of a body occupies the lowest possible position. Draw a line in this direction. After doing this, suspend the body from another position. The centre of gravity now will be in the line drawn in prolongation of the thread this time for the reasons just given. Draw a line in this direction. If the drawing is properly done, both of the lines meet and the place where they meet is the centre of gravity of the body,

Q. 24. -What is meant by the equilibrium of a body? State the different kinds of equilibrium which bodies may be in, and explain the difference.

Ans.—Equilibrium means the state of rest which a body may possess under the action of the different forces acting on it.

Stable equilibrium, *unstable equilibrium*, and *neutral equilibrium* are the three kinds in equilibrium. If a body returns to its former position after being disturbed, it is said to be in a *stable equilibrium*. This will be the case if the centre of gravity of the body be in its *lowest possible position*. A book suspended by one of its corners is an example of a body in stable equilibrium. In all similar cases, where the centre of gravity of a body is exactly below the point of support, the body will be in a stable equilibrium. A book lying flatly on a table is also in a stable equilibrium.

If a body, after being disturbed, does not return to its former position but assumes a different position altogether, it is said to have been in an *unstable equilibrium*. This would be the case if the centre of gravity of the body be not in its lowest position. A book held up by one of its corners is an example of a body in an unstable equilibrium. A little disturbance will make it move away from its position and assume a new position such that its centre of gravity is in its lowest possible place. In all similar cases, where the centre of gravity of a body is above the point of support, the body will be in an unstable equilibrium. A book made to stand on a table on one of its edges is also in an unstable equilibrium.

If a body remains at rest in any position in which it may be placed, it is said to be in a *neutral equilibrium*. A cricket ball placed on a

table is in a neutral equilibrium. So also is a circular piece of cardboard supported at its centre by a wire passing through it.

Q. 25.—Explain 'the vertical line' and its relation to the stability of a body.

Fig. 2.

Fig. 3.

Ans.—The line drawn from the centre of gravity of a body towards the centre of the earth is called its *line of direction*. It is also called the vertical line and has an important relation to the stability of the body. If this line falls within the base of the body, it will stand; if it falls outside the base, it will be overturned. Fig. 2 represents a body with its line of direction falling inside the base. It, consequently, continues to stand. Fig. 3 represents a body with its line of direction outside the base and, in consequence, it will be overturned at once unless prevented from doing so.

Q. 26.—With a watch and a stone how could you find out the height of a high tower if you were up on the top of it? *Pun. Ent., 1901.*

Ans.—Bodies that fall from a height under the influence of gravity go on increasing their velocity regularly. They undergo a uniform acceleration of thirty-two feet per second per second. The space passed over by a falling body can be found out by noting the time during which it falls. When there is no velocity possessed by a falling body at starting, the space passed over by it varies as the *square of the number of seconds* during

which it falls. It has been found that the space passed through by a falling body is equal to $16\ t^2$ where 't' represents the number of seconds during which the stone has fallen. Therefore, I would drop the stone down and note with the watch the number of seconds it has taken to reach the earth. Squaring this number and multiplying it by 16 I shall be able to know the number of feet passed over by the body during the time. The space passed over by it is the same as the height of the tower. Thus the height of the tower could be determined.

Q. 27.—Give any four illustrations of the truth that bodies tend to place their centre of gravity as low as possible. M.U., 1881.

Ans.—(1) A book held up between the fingers will, on a slight disturbance, be overturned. (2) A rod made to stand on its end will fall down quick. (3) A man walking on stilts will be liable to fall flat on the ground. (4) A child's cradle, when pushed aside, comes back.

Q. 28.—Give three examples where the centre of gravity of a body happens to be outside its matter.

Ans.—(1) In the case of a ring, (2) in the case of a tennis ball, and (3) in the case of a glass globe, the centre of gravity is outside the mass.

Q. 29.—Two uniform discs, A and B, are freely suspended in vertical plane by strings, A from a point one inch below and B from a point one inch above the centre. What will take place, if each disc is slightly displaced and why? M.U., 1889.

Ans. 'A' is in unstable equilibrium, because the centre of gravity is above the point of support. On being displaced, it overturns and places itself in such a position that the centre of gravity may be below the point of support exactly.

'B' is in stable equilibrium, because the centre of gravity is exactly below the point of support. On being displaced, it will move and come back to its former position after making a forward and backward motion for sometime.

Q. 30. 'The centre of gravity of a solid sphere is exactly at its centre.' Is this true in all cases? Explain and give examples.

Ans.—It is not true in all cases. The centre of gravity of a body depends upon the distribution of matter in it. Therefore, the centre of

gravity of a solid sphere is exactly at its centre, only when it is a uniform sphere. In a wooden sphere, for example, the centre of gravity is exactly at its centre; but if a part of the sphere be replaced by lead, the centre of gravity will not be at the centre of the sphere, but will be in some other part of the ball nearer the lead.

Q. 31.—Describe the common balance.

Fig. 4.

Ans.—The balance is an instrument by means of which the *relative weights* and thereby the *relative masses* of bodies may be determined. It consists of the following parts: (i) *A beam*, which is a lever of the first order, the fulcrum of which is exactly in the middle. (AB, Fig. 4.) (ii) *Two scale pans* (C and D) suspended at the extremities of the beam, one of which receives the things to be weighed and the other the counterpoise. (iii) A *pointer*, attached to the beam to show the excess in weight of the body or of the counterpoise. When the body and the counterpoise are of equal weight, the pointer stands vertical, and so does it when the scale pans are empty. The distance between the fulcrum and the point of suspension of the scale pan is called an *arm of the balance*. Every balance, therefore, has two arms.

[In answering questions of this kind, first, I give the use and purpose of the instrument; then, mention its different parts and show them in a figure.]

Q. 32.—State the conditions to be fulfilled by a good balance. How does the position of the centre of gravity in a balance affect it?

Ans.—(i) *It ought to be just, i.e.*, the beam must be perfectly horizontal when the contents of the scale pans are exchanged. In order that a balance may be just, *its two arms must be exactly equal.* (ii) The balance must be in equilibrium when the scale pans are empty. (iii) *The balance must be delicate, i.e.*, even a little difference in weight must be clearly and distinctly indicated. For this purpose *the centre of gravity of the beam* must be vertically a little below the fulcrum.

If the centre of gravity of the beam be a little above the fulcrum, then it would be in an unstable equilibrium, and even a slight difference in the weights of things in the scale pans will disturb the balance very much. If, on the other hand, the centre of gravity of the beam should coincide with the fulcrum, then the beam would be in a neutral equilibrium and the balance fails to be sensitive.

Q. 33.—Even if a balance be not just the true weight of a body may, nevertheless, be determined by its means. How could it be done?

Ans.—"Put the body to be weighed in one pan and counterbalance it with sand or other suitable material in the other. Then remove the body and put in its place such weights as are just sufficient to counterpoise the sand. These weights are evidently equal to the weight of the body."

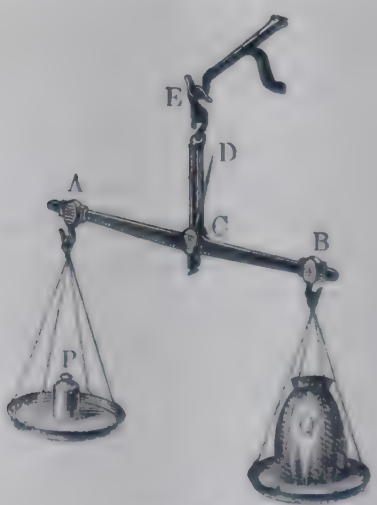

Fig. 5.

Q. 34.—Draw two sketches of a common balance (i) with equal weights, (ii) with unequal weights in the pans, and mark where the centre of gravity of the whole is in each case.—M.U., 1893.

Ans.—See the figures 4 and 5. In the first case, the centre of gravity of the balance is a little below the fulcrum; in the second case, the centre of gravity of the balance and the weights will be towards the greater weight.

Q. 35.—Explain what is meant by 'a Law' in science. State the 'laws of capillarity,' and draw figures to show the capillary elevation and capillary depression.

Fig. 6 to illustrate capillary depression.

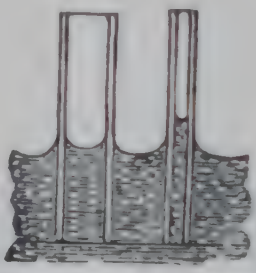

Fig. 7 to illustrate capillary elevation.

Ans.—The word 'Law,' in science, does not mean a rule. It simply means a statement of facts which are observed to happen invariably in connection with any phenomena, so that the phrase 'laws of capillarity' means *the facts which are invariably observed wherever capillary phenomena occur*.

The Laws of Capillarity are.—(1) in cases where the liquid does not wet the solid, there will be capillary depression; but, if the liquid wets the solid, there will be capillary elevation; (2) the ascent or descent of the liquid *in a tube* placed in it depends upon the diameter of it—the narrower the tube, the greater the ascent or descent. These two statements are known as laws of capillarity.

Q. 36.—Explain the following terms:—Cohesion, capillarity, limit of perfect recovery of a body.—Pun. Ent., 1902.

Ans.—*Cohesion* is the force which exists in nature, and in virtue of which the various particles of a body are held together.

Capillarity is that force in virtue of which a liquid rises above its level (or sinks below its level), when it comes into contact with a solid.

Limit of perfect recovery of a body is the extent to which that body may be distorted without destroying its power of resuming its former shape completely, when the distorting force is removed.

Q. 37. State the importance of capillarity and friction in nature and daily life.

Ans.—(It is owing to capillarity that water rises into a sponge or a lump of sugar placed in contact with it. (2) Oil rises into the wick. (3) Water rises into the highest parts of the tree also. (4) Ink is taken up by the blotting paper.

The importance of friction cannot be over estimated. "We could not exist without it. In the first place we could not move about, for walking is only possible on account of the friction between the soles of our feet and the ground ..... objects could only be handled with difficulty, nails would not remain in wood, and screws would be equally useless." Among the numerous instances in which friction is made use of to stop a moving body, we may mention the brake used in stopping a railway train. The essential parts of this contrivance are shown in Fig. 8. SS is the brake, and by turning the handle M, the brake is made to press against the rolling wheel RR, which thereby stops at once.

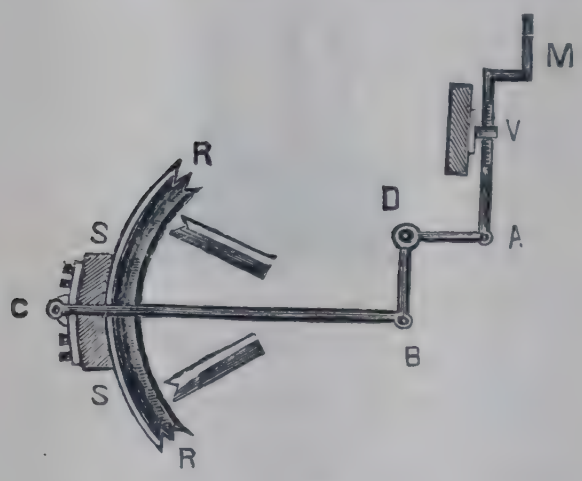

Fig. 8.

Q. 38.—A drop of water or ink on a surface can be removed by means of blotting paper, but we cannot remove a drop of mercury in this way. Describe simple experiments to show the reason.—M.U., 1891.

Ans.—Dip a pen into ink, and the ink rises in the slit.

Bring a piece of ash into contact with water, and the water rises into the mass of it.

Allow a part of your cloth to fall into water, and soon after, the water will be seen to rise into the adjoining parts also.

Dip your finger into mercury, the mercury round your finger will be seen to go below its level, and on taking it out your finger will be seen not to be wetted by mercury.

Dip your pencil into mercury, the same thing happens.

These facts prove that a liquid rises above its level in those cases where it comes into contact with a solid which it wets, otherwise it does not. There is no adhesion between the blotting paper and mercury, but there is adhesion between water and paper. Hence ink can be taken up by blotting paper but not mercury.

Q. 39.—If you were given a steel bar, a yard measure and a pound weight, how would you use them to determine the weight of some substance?—M.U., 1891; Pun. Ent., 1900.

Fig. 9.

Ans.—Suspend the weight from one end of the steel bar and the substance from the other end. Hold the steel bar by means of a thread somewhere between the pound weight and the substance. Hold it in such a place that the bar may be horizontal. Now, measure the distances of the weight and the substance from the place of support. This can be done by the yard measure. P × P A = W × W A is the condition of equilibrium in levers: P is power; P A is power arm; W is weight; W A weight arm. The weight of the substance can be determined with the help of the relation given above. [Fig. 9.]

Q. 40. A wooden beam is supported in a horizontal position at both ends and weights are hung from the centre. What is the relation between the weight and the bending it produces? Show clearly by means of a diagram what the bending is and show how it is to be measured.—M.U., 1896.

Ans.—The bending produced in the beams is *nearly* proportional to the weights suspended from the centre. From the greatest part of the bend draw perpendiculars to the *straight line* joining the two ends of the beam. These perpendiculars represent the extent of the bending; see Figs. 36 & 37.

Q. 41.—Why is it that in erecting a building an engineer places the beams so as to have the greatest possible depth and uses beams strong enough to bear 5 or 6 times the greatest weight that will be put upon them ?—M.U., 1888.

Ans.—The same beam placed edgewise can support a much greater weight without bending to the same extent than when placed breadthwise (flat).

He uses beams strong enough to bear 5 or 6 times the greatest weight that will be put on them because, "Sometimes a building may be strong enough to stand a heavy weight on the floor and yet the floor of the building may be so much bent that it won't quite recover itself when the weight is taken off. In such a case, the floor will be less strong each time the weight is put on it." It is to prevent the structure from ever bending beyond the limits of perfect recovery that such strong beams are used.

Q. 42.—You are given a flat ruler and a basin of mercury. How could you determine by these things whether the edges of the ruler are paralled or not ?—M.U., 1892.

Ans.—The mercury in the basin is in a perfect level. The surface is horizontal. Therefore, the flat ruler is to be held over the mercury, perpendicular to its surface in such a way that one edge of the ruler may be in the same straight line with its reflection in the mercury. Then we are to examine if the other edge of the ruler also is in the same straight line with its reflection in the mercury. If so, the two edges are parallel. If not, they are not.

Q. 43.—A night-lamp consists of a cup with some oil floating on the top of the water. The wick dips partly in water. Explain whether, by the law of capillarity, the water will rise up and prevent the burning of the wick or not.—M.U., 1881.

Ans.—No. The oil in the wick prevents the water from getting into it. Oil has adhesion to the matter of the wick just like water. But there is no adhesion between water and oil ; therefore when once the oil gets into the wick water does not rise in it although the wick is partly in the water.

Q. 44.—What is meant by the velocity of a moving body (*a*) when it is uniform, (*b*) when it is varying ?—M.U., 1903.

Ans.—(*a*) The velocity of a moving body is said to be uniform when the body goes over equal distances in equal intervals of time.

Acc No
Sec No
BANGALORE.

(*b*) The velocity of a moving body is said to be varying when it does not pass over equal distances in equal intervals of time.

When a man walks steadily over two miles every hour, his velocity is uniform; if he changes his rate and goes over 2 miles in one hour, three miles in the next and so on, his velocity is varying.

Q. 45.—How is the velocity of a body measured (*a*) when it continues the same, (*b*) when it varies while the body is moving?—M.U., 1901.

Ans.—(*a*) By noting the space passed over in a given time, the velocity of a body is measured when it continues the same. The unit of time is one second. A body moves at 30 feet per second, means that it goes over 30 feet every second.

(*b*) When the velocity is variable, it is measured by noting the space passed over in any particular interval of time. Calculation is then made what its rate would be if it continued its motion at the same rate. Seeing a horse running quickly, one says that it is going at the rate of 20 miles per hour. This does not mean that the horse has been running for one hour, or throughout at that rate; it simply means that, if the horse should continue at that rate for one hour, it would pass over 20 miles of space.

Q. 46.—Explain why a man carrying a weight in one hand cannot walk upright.

Fig. 10.

Ans.—Ordinarily, the perpendicular dropped from the centre of gravity of a standing person falls within the feet. Therefore, when a man walks, he walks upright. When he carries a weight in his right hand, he adds something more to his body. The additional mass disturbs the position of the centre of gravity. To adjust the centre of gravity so that the perpendicular from it may fall within the feet, he bends in the way shown in the figure.

UNANSWERED QUESTIONS.

Q. 47. –What is the difference between the mass and the weight of a body: State exactly the relation which holds good between them. —Pun. Ent., 1903.

48.—Distinguish between velocity and acceleration. —B.U., 1899.

49.—Explain clearly what happens to a man driving fast when the horse suddenly stops.

50.—Why does a man carring a heavy load on his back bend forwards?

51.—What are the physical forces at work (1) when writing in ink, (2) when a lamp in which a candle burns hangs from the roof by a chain?

52.— Mention four of the forces of nature. Give illustration of their action and state their distinctive characteristics.

53.—Describe an experiment justifying the practice of putting in the ceiling of rooms rafters of rectangular cross-section so that the depth is greater than the breadth. Why are the rafters not made so that their cross-section is square?

54.—What is meant by a property of matter? State and explain two properties common to all kinds of matter.

55.—What should a man do to get into a running tram car safely? Explain the principle on which his action is based.

56.—What is meant by the *limit of perfect recovery*? Of what use is its knowledge to an architect?

57. –What is meant by the *line of direction*? State clearly its relation to the stability of a body?

58.—Distinguish between ductility and malleability.

Mention two substances which are not ordinarily ductile and which become ductile under some conditions.

59.—Define force, and show that the attraction that the earth has for bodies satisfies your definition.

60.—A man sits in a running tram car. How would he be affected if it suddenly turn a corner to his right?

61.—What is meant by the centre of gravity of a body? How would you ascertain the position of the centre of gravity of a rod, for instance, the pen-holder you are using.—M.U., 1897.

62.—What is meant by the centre of gravity of a body? Explain with the aid of diagrams the position assumed by a balance, (1) when the scales have each equal loads, (2) when they have unequal loads.—M.U., 1899.

UNANSWERED QUESTIONS—*contd.*

63. How would you find the centre of gravity of a cubical vessel? If set upright, would it be rendered more or less stable if it were half filled with sand?—M.U., 1900.

64. Sketch and describe the common balance. Why could not the balance have its centre of gravity above the point of suspension upon which the balance is swung? What makes the balance come back to a definite position when tilted aside?

65. How would you manage to ascertain the correct weight of things with a balance with unequal arms?

66. What are your reasons for saying that friction is a force?

67. (*a*) Explain the cause of the attitude of (i) a fat man walking, (ii) a man carrying a load on his back, and (iii) a man rising from a chair. (*b*) Explain the principle of loading the bottom of a candle stand.

68. Two persons, X and Y, carry a weight of 100 lbs. suspended by a rope to a beam. Find the pressure felt by each, if the weight be 3 feet nearer X than Y, the beam being 18 ft. long.

69. Persons driving in a coach feel a jerk whenever the horse is whipped. Why is that? Do the persons in the opposite seats receive the jerk exactly in the same way? Account for your answer.

70. What is meant by the equilibrium of bodies? State with reasons the kind of equilibrium in the following cases: (1) a candle stand with the bottom not weighted; (2) a marble placed on a table; (3) a book lying on a table; (4) the cradle of a child.

71. Describe an experiment to show that the strength of a structure depends upon its form, and give drawings to illustrate your answer.—M.U., 1899.

72. What is meant by the density of a body? Explain what you would do to compare the densities of two bodies.

73. Explain why a cartload of straw is more liable to be overturned than an equally heavy cartload of iron, and why a man carrying a heavy pitcher of water in one hand cannot walk with his head erect.

74. Explain clearly why the beam of a balance slants when unequal weights are placed in the scale pans.

75. A pen is dipped into an ink bottle and is taken up full of ink. State the various forces that come into play.

76. If we could visit the centre of the earth, we should find there matter without weight, although its other properties remain unchanged. Explain this.

77. Distinguish carefully between the properties of matter in the solid, liquid and gaseous states. What experiments would you propose

to make in order to determine in which state a given sample of matter was ?—L.U., 1901.

78. The head of a hammer is more firmly fixed by striking the end of the handle against the ground. Explain this.

79.—How does the motion of a falling body differ from that of the hands of a clock ? How would you prove this difference ?

SECTION II.

SOLIDS, LIQUIDS, AND GASES.

Q. 80. Enumerate the various states in which matter exists in nature, and briefly state the physical properties of each state.—Pun. Ent., 1900.

Ans.—The various states in which matter exists in nature are three—solid, liquid and gaseous. The points of difference in the three states are given in the following tabular form :—

Solids.	Liquids.	Gases.
i. Solids have definite shape and definite size.	i. Liquids have no definite shape.	i. Gases have no definite shape or size.
ii. It requires force to alter the shape of a solid.	ii. It requires but little force to change the shape of a liquid in any vessel.	ii. There being repulsion among its particles, a gas always tries to occupy a greater space, if allowed.
iii. It will be easy or difficult to change the form of a solid according as the degree of cohesion among its particles is less or greater.	iii. Liquids have a definite size.	iii. A gas, in order to retain a particular volume, must be kept under pressure.
		iv. A gas has not a free surface.

Q. 81. Describe any simple experiments to show that liquids have some cohesion but gases none.—M.U., 1887.

Ans.—Take an oiled paper and sprinkle a few drops of water over it. The water will be seen to assume a globular form.

Between two glass discs press small globules of mercury. It will be seen that the globules are flattened. Separate the discs now, and the mercury will be seen to assume its globular form again.

These two experiments show that the particles of a liquid come together and form globules on account of cohesion in them.

Exhaust the air from the receiver: as the exhaustion proceeds, the air left behind will be found to occupy the remaining part of the jar.

Exhaust a glass globe and connect it with another which has not been exhausted. The air will rush from the latter to the former.

These two experiments show that the air tries to occupy a larger space because the particles of air try to run away from one another owing to the repulsion amongst the particles.

Q. 82.—State the properties peculiar to liquids and describe experiments whereby these properties may be illustrated.

Ans.—(1) **Liquids are almost incompressible.**—The following experiment shows the incompressibility of liquids. "If a vessel is filled with water, and then a tight-fitting cork is forced down into the neck, the vessel will burst, although the water has been but very little compressed." Liquids are not, however, completely incompressible. They can be slightly compressed. (2) **"Pressure exerted anywhere upon the mass of a liquid is transmitted undiminished in all directions, and acts with the same force on all equal surface, in directions at right angles to those surfaces."**

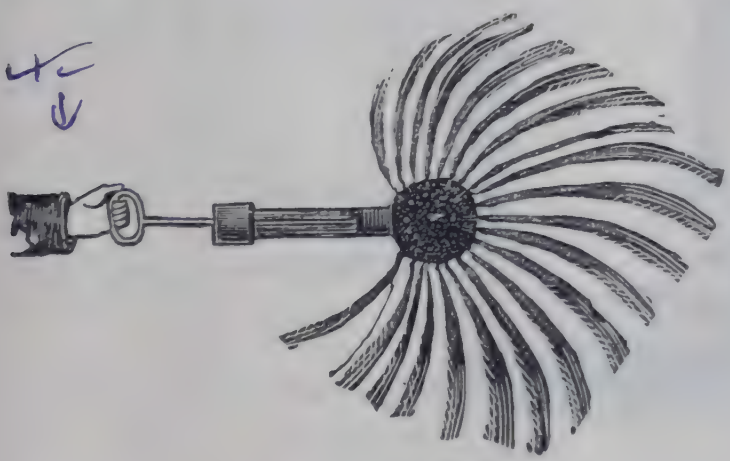

Fig. 11.

This is known as Pascal's Law of equality of pressures, for it was first discovered by him. It may be demonstrated thus. Take a syringe ending in a hollow sphere, having holes all over it. Fill it with water. Push the piston in. The liquid rushes forth from all the holes in the sphere and not merely from those opposite to the piston. The action of this syringe shows that pressure exerted upon the mass of a liquid is transmitted in all directions and at right angles to the surfaces of the area affected. (Fig. 11.)

Again take two cylinders, A and B (Fig. 12), of different diameters connected by a tube and provided with water-tight pistons moving in them. Fill the cylinders with water. If the area of the larger piston Q be 25 times that of the smaller piston, then a weight of 2 lbs. placed on the piston P will be counterbalanced only by a weight of 50 lbs. placed on Q. This shows that the pressure applied on any part of the liquid is communicated in all directions *without being diminished;* because the pressure of 2 lbs. applied on the small piston acts with the same force (*i.e.*, of 2 lbs.) on all equal surfaces in the other cylinder. The other cylinder contains 25 equal surfaces, for the bigger cylinder is 25 times the smaller one. A force of not less than 50 lbs. counterbalances a weight of 2 lbs. placed on the smaller piston. This shows that the pressure of 2 lbs. applied to the water in the small cylinder is communicated to the water in the other cylinder undiminished.

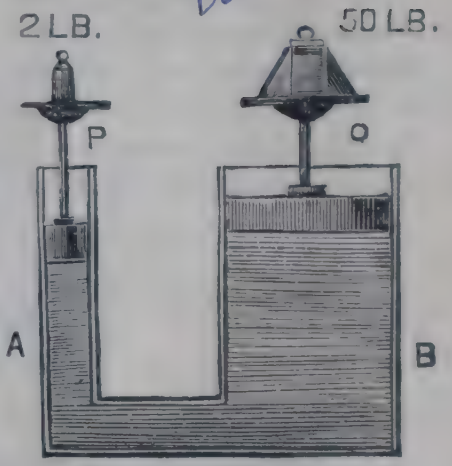

Fig. 12.

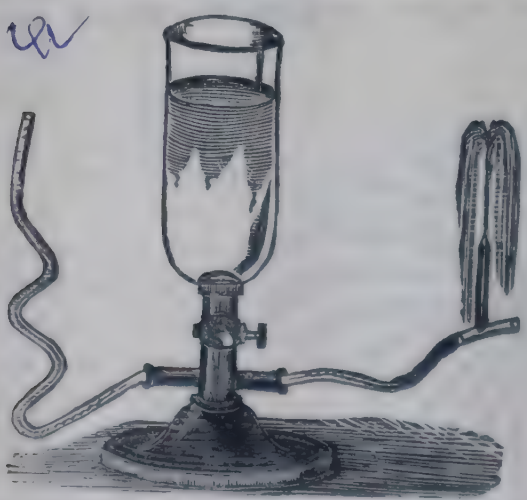

Fig. 13.

(3) **Liquids find their level.**—Liquids placed in communicating vessels tend to assume a uniform level. Fig. 13 shows an arrangement which illustrates this truth. An examination of the last tube shows that the liquid spurts up nearly to the level of the water in the principal vessel.

Q. 83.—Draw an outline sketch, and give a brief description, *in your own words*, of the Brahma Press.—M.U., 1881; 1885; 1902; and state particularly on what two properties of liquids its mechanical value depends.—M.U., 1881; 1897; 1902.

Ans.—Fig. 14 gives a general view of its various parts, which are: (1) An arrangement marked A [a force-pump] by means of which water

from the reservoir can be forced into the bigger cylinder B through the tube T by moving the piston up and down. (2) A cylinder, B with *very strong* sides in which a cast-iron ram (C) works water tight. The ram rises if water is forced into the cylinder B.

(3) On the ram there is a cast-iron plate to receive the substances, and this when raised presses against a fixed frame.

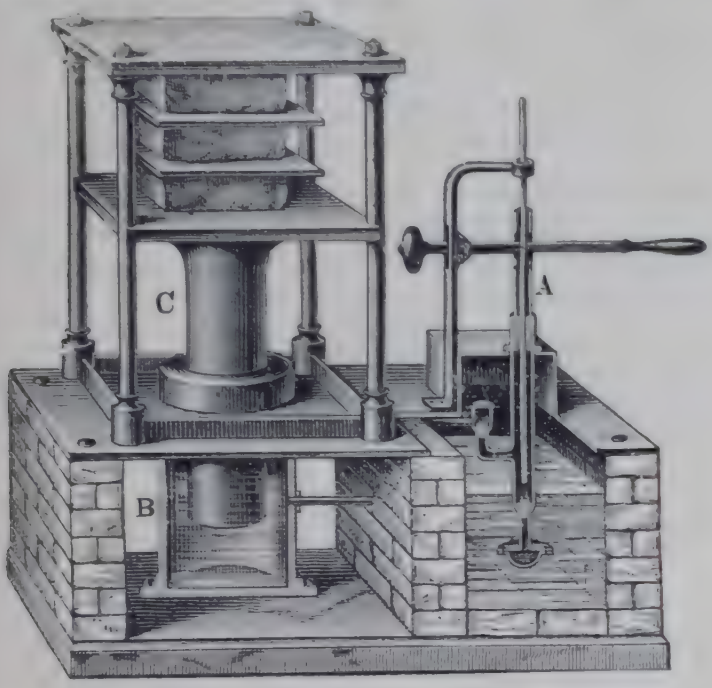

Fig. 14.

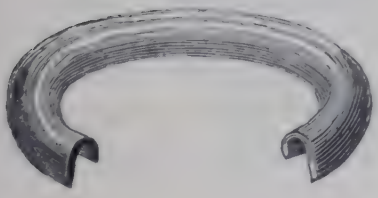

Fig. 15.

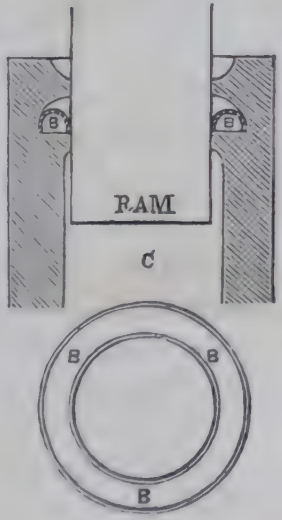

Fig. 16.

Its Action.

Make the piston move up and down. Its effect is to force the water from the the reservoir into the cylinder B. Liquids are incompressible, and, therefore, the water forced into the cylinder B cannot be compressed, and consequently it raises the ram C. The ram will be pressed up with a very great force. When the ram is pressed up, the plate on it also is forced up along with it against the fixed frame above, and the things on it are compressed.

When the water is forced into B the ram rises; but on account of the great pressure produced by the forcing of the water into the cylinder, the water may leak away round the ram however tight it may be. This is remedied by placing a circular leathern collar (shown separately, fig. 15) open on the lower side, in a groove of the cylinder. "The water forcing its way up the cylinder B enters the collar and presses it against both the ram and the sides of the cylinder, thus making it a water-tight joint." Thus the water is prevented from leaking away round the ram. Were it not for this collar, the working of the machine would not have been possible. This collar was invented by Brahma and, hence, the machine is called after his name. The position of the collar round the ram is shown in figure 16.

Its mechanial value depends chiefly upon two of the properties of liquids, *viz.*, (1) Liquids are incompressible. (2) Pressure applied anywhere on the mass of a liquid is transmitted in all directions and acts with the same force on all equal surfaces.

Q. 84.—If a force of 28 lbs. on the small piston of a Brahma Press produce a pressure of 1 ton on the large piston, how many times is the area of the latter greater than that of the former?—1885.

Sol.—The pressure exerted by a liquid is proportional to the area affected.

On the large piston the pressure is 1 ton: on the smaller piston the pressure applied is 28 lbs.

$\therefore$ the area of the larger $= \frac{2240}{28} = 80$ times the smaller piston.

Q. 85.—The area of the small piston of a Brahma Press is 1 sq. in. and that of the other is 100 sq. in.; the lever is 30 in. long and the piston is placed at a distance of 6 in. from the fulcrum. If a pressure of 40 lbs. is applied to the lever, what pressure will be produced upon the larger piston?

Sol.—The lever is that of 2nd order. Weight between F and P

Here PA=the length of the lever=30 in.

WA=6 in. $\therefore$ the mechanical advantage is 5.

The pressure applied to the lever = 40 lbs.

$\therefore$ the piston moves with a force of $5 \times 40 = 200$ lbs.

The larger piston of the press being 100 times that of the smaller piston, a force of 1 lb. on the smaller produces pressure of 100 lbs. on the larger one.

∴ A force of 200 lbs. on the smaller produces a pressure of 200 × 100=20.000 lbs. on the larger.

Q. 86.—In a Brahma Press the smaller piston is 3 sq. in. and the larger 270 sq. in. Calculate how far the larger will rise when the smaller piston moves through 1 in. and account for your answer.

Ans.—The larger piston is 270 sq. in.; the smaller is 3 sq. in.;

i.e., the larger is 90 times the smaller.

∴ By the time the smaller moves through 1 in. the larger rises through $\frac{1}{90}$ of an inch.

The reason is that the water forced into the larger piston when the smaller moves through 1 in. distributes itself in the larger cylinder over an area of 270 sq. in. The water in the larger cylinder, therefore, rises by $\frac{1}{90}$ of an inch. Hence the larger piston rises through that space.

Q. 87.—The general principle upon which machines work is, "whatever is gained in power is lost in speed." Explain this with reference to the working of the Brahma Press and of a lever.

This means that, by using a machine, we may gain in the way of power, but we shall not be able to do things as quickly; and in some cases we may gain in speed, but we shall lose in power. To understand this, refer to Fig. 17.

Fig. 17.

It represents a lever of the first order. Its power-arm PF is five times the weight arm WF. Now suppose you want to raise a weight of 20 lbs. with it; you can do that by applying only a power of 4 lbs. because the mechanical advantage is 5; but by the time the power moves through PR the weight rises only through WS. As you can see at once,

we gain in power, because we can raise a weight of 20 lbs. by a power of 4 lbs. only; but we lose in speed, because when we move the power through a greater distance P R, the weight rises only through a smaller space W S. Again, question 86 tells us that the force with which the larger piston rises is 90 times the force with which the smaller piston is worked. But the space through which it moves is only one-ninetieth of the space through which the smaller moves, in other words, we lose in speed exactly what we gain in force. Hence "whatever is gained in power is lost in speed."

Q. 88.—Describe the water-level and state clearly the principle on which its action depends.—M.U., 1883.

Ans. The instrument "consists of a horizontal metal tube with a vertical glass tube at each end standing at right angles marked and graduated, *i.e.*, divided into degrees. The instrument is supported by a stand, having a joint which enables the user to turn it in any direction." It is used in ascertaining the difference of level between two places (fig. 18).

How to use the instrument.—"Water is poured until it rises in both legs. When the liquid is at rest the level of the water in both tubes is the same; that is, they are both in the same horizontal line. If it is desired to find the difference between the heights of two places a levelling staff is fixed on the distant place. This staff consists of a rule, formed of two sliding pieces of wood, one of which supports a piece of tin plate, in the centre of which there is a mark. The staff being held vertically, an observer looks at it through the level along the surfaces in the two tubes and directs the holder of the staff to raise or lower the slide until the mark is in the line of the level in the two tubes. The assistant then reads off on the graduated rod the height of the mark above the ground. If this height exceeds that of the level, the height of the latter is subtracted from that of the former and the difference gives the difference in the heights of the two places."

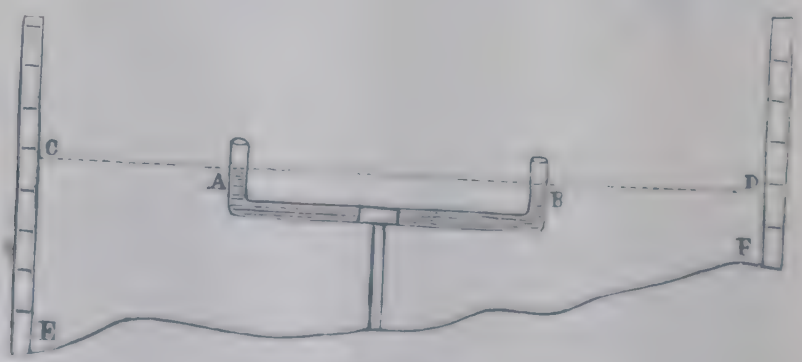

Fig. 18

The principle of its action :—Liquids in communicating vessels maintain the same level.

Q. 89.—State the exceptions to the rule that liquids find their level.

Ans.—To the statement that liquids find their level there are three exceptions : 1st, when it happens to be in a very small quantity : then it assumes a globular form. 2nd, when it is in a great body as in the case of the sea ; then it takes the spherical form of the earth which it encircles : and 3rd, when it is disturbed by external forces, such as capillarity, in which case the liquid rises above, or sinks below, its level. Again, a liquid constantly moving, as for example, a stream which flows from a higher level to a lower level will not be at the same level throughout, although the flowing itself illustrates its tendency to assume a level.

Q. 90.—Sketch and describe the spirit-level. Account for its different names and state the properties of liquids and gases that enable us to use the instrument.

Ans.—The Spirit-level is an instrument by means of which we can find out whether any given surface is perfectly plane or not. It consists of a wooden frame or a brass case containing glass tube slightly curved and filled with alcohol except a small space which is occupied by an air-bubble.

Fig. 19.

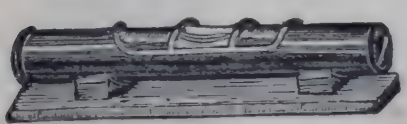

Fig. 20.

To make a spirit-level, a slightly bent tube (fig. 20) is taken. It is filled with the liquid called alcohol. A small space is left unfilled, and this contains air. This air-bubble occupies the highest part of the instrument. The instrument is now mounted in a wooden frame or a brass case (fig. 19) and the highest part left exposed to view as in the figure.

How it is used :—The instrument is placed on the surface which is to be examined, as shown in the figure. The position of the air-bubble is then observed. If it appears at the highest part of the instrument left exposed to view then *the parts of the object under the instrument* must be taken to be perfectly level. Thus, it is to be placed on the different parts of the object to be examined.

The instrument is also known by the names of (1) air-level and (2) air-bubble-level, on account of the air-bubble being a very important part of the instrument.

Gases are lighter than liquids, bulk for bulk. *Liquids* are heavier than gases. Therefore, when a liquid and a gas are mixed together, the liquid remains at the bottom and the gas at the top.

Q. 91.—How would you proceed to find out whether a spirit-level is accurate or not?

Ans.—Place the instrument on a perfectly plane surface. See if the air-bubble is at the highest part of the instrument in that position. Next, exchange the positions of the ends of the instrument. Observe where the air-bubble appears now. If in both of the two positions the air-bubble appears at the highest part of the instrument, then the instrument may be taken to be accurate.

Q. 92.—State and explain some of the uses to which the instrument is put.

Ans.—(1) It is of great use to carpenters and other mechanics who can find out by its help whether the required part of the article made is perfectly plane or not.

(2) It can be used to find out whether a bracket on which the clock stands is perfectly level.

(3) It is attached to the telescope, used in ascertaining the difference of level between two distant places.

[*Explanation for* (3).—Telescope is an instrument by means of which we can see the distant objects which cannot be seen without its help. In observing the difference of level between two distant places a telescope is used sometimes. Then, it is of great importance to see if the observing telescope itself is in a perfectly horizontal position. For this purpose, a spirit-level is attached to the telescope and the proper position of the telescope obtained.]

Q. 93.—Distinguish carefully between "pressure of the atmosphere" and "the weight of the air." Illustrate your answer by a description of two experiments.—M.U., 1886. Describe an experiment that will illustrate the difference between the pressure of air due to its weight and the pressure due to its elasticity.—M.U., 1882.

Ans.—The air is matter. Since matter is attracted by the earth and possesses weight the air also possesses weight. To see this take a glass

globe provided with a stop-cock and find out its weight after having exhausted it. Then admit air into it, and weigh it. It will be found to weigh more showing that the air has weight.

Being a fluid, the air exerts pressure on bodies in it, just as water and other fluids do. This pressure depends upon the column of the air above the body. It is the pressure of the air that sustains the column of mercury in the barometer. To see this, fill a barometer tube with mercury and having closed the open end with a finger, invert it carefully into a basin containing mercury. A part of the mercury in the tube will fall down into the basin. If the whole is now taken to the top of a mountain the column will become shorter, for the pressure of the air there cannot support so much as before, and hence some more mercury in the tube falls into the basin. The pressure due to its weight is exerted downwards. The pressure of the air due to elasticity acts in all directions. To see the pressure due to its weight, tie to the neck of a belljar a sheet of india-rubber, fix it on to the bed-plate of the air-pump, and go on working the instrument. The piece of india-rubber at the top will be seen to go down (Fig. 21).

Fig. 21.

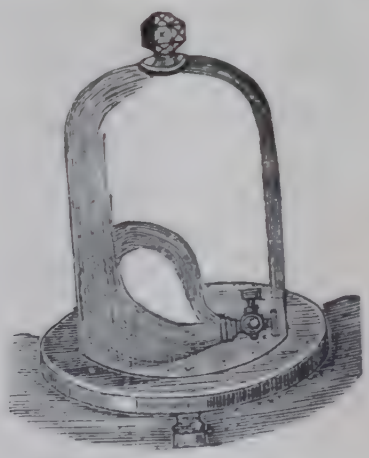

Fig. 22.

To see the pressure due to 'elasticity' lace a hollow india-rubber bag under that receiver before hand. As you go on exhausting the air the bag will be seen to become larger and larger (Fig. 22), because the air in the receiver is removed and the pressure of the air outside the *bag* is thus reduced. The elastic pressure of the air inside the bag makes it swell up.

Q. 94.—Two large bottles, one filled with water, the other half filled with water and half with air, are tightly corked; a tube open at both ends is passed through the cork of each and reaches nearly to the bottom of the bottles. Describe what would happen if these bottles were carried up in a balloon. M.U., 1883.

Ans.—The water in the bottle half filled with air flows out through the tube, but the water in the other bottle does not. For the higher we go, the less is the pressure of the air. But the pressure of the air, in one of the bottles, will remain the same as on the surface of the earth and thus will be in excess of the pressure of the air at the place where it has been carried So, the water in the bottle half filled with air will be forced out of the tube. The other bottle is full of water and hence the change in the external pressure does not affect it.

Q. 95.—(*a*) I fill a barometer tube 3 feet long with mercury and, closing its end with my finger, invert it in a basin of water. What will be the result on removing my finger and why?

(*b*) Under what circumstance will a V-shaped tube with equal legs act as a syphon?—M.U., 1882.

Ans.—(*a*) The mercury being heavier bulk for bulk than water, falls into the water in the basin. The water rises to take its place and fills the tube completely, for the tube is only 3 feet in height and the atmosphere can support a column of 33 feet of water, nearly.

(*b*) (1) The tube must be filled with the liquid to be transferred.

(2) One leg must, then, be introduced into the liquid and the other left outside.

(3) The perpendicular height of the tube in the liquid must not exceed the column of the liquid which the atmosphere can support there.

(4) The liquid continues to flow, so long as the end of the outer tube continues to be below the level of the liquid in the vessel.

Q. 96.—Briefly describe Torricelli's barometer experiment and state clearly what it teaches us.—M.U., 1887.

Ans. Take a tube of about 33 inches closed at one end and open at the other. Fill it with mercury, and close the open end with a finger (as in fig. 23). Invert it into a basin containing mercury and take out your finger only after the open end has gone below the surface of the mercury in the basin as shown in the figure. As soon as the finger is removed, a part of the mercury in the tube falls into the basin, leaving a vacuum at the top as you see in the figure. The remaining mercury in the tube stands at a certain height and denotes that the pressure of the air can support a column of mercury of that height. Thus the use of a barometer is to tell us the pressure of the air. We learn from this experiment (1) that the pressure of the air is *definite* in any given place and (2) that it can be measured. For example, at the sea level the barometer stands very nearly at 30 inches, *i.e.*, the mercurial column above referred to will be 30 inches long. This means that the pressure of the atmosphere there is equal to the pressure exerted by a mercurial column of 30 inches; so that, if the air above be removed and mercury to a depth of 30 inches be substituted for it, the pressure on the surface of the earth there would be the same. Therefore, the total weight of the surrounding atmosphere of the globe is equal to the weight of a sea of mercury round the earth 30 inches deep. From this we come to know that on every square inch of the surface of the earth the pressure of the atmosphere is very nearly 15 lbs. (which is the weight of a column of mercury whose length is 30 inches and whose cross-section is 1 square inch).

Fig. 23.

Q. 97.—A barometer is placed so as to stand on a flat plate, and is covered with a glass receiver which fits air-tight to the plate. Will the barometer continue to show the changes in pressure of the external atmosphere? Give reasons for your answer.—M.U., 1888.

Ans. -No. In this case the barometer is cut off from communicating with the external air and, hence, the changes in the external air cannot affect the column of the barometer in the receiver.

Q. 98.—Why does the mercury in a barometer stand higher at the foot than at the top of a mountain? What practical use can be made of this?

Ans.—The higher we go, the less is the pressure of the air. The barometric column becomes shorter as we go higher. The air is less dense at the top than at the foot of a mountain. Hence the column stands higher at the foot than at the top of a mountain. It has been found that the barometric column falls at a certain rate as we ascend. With the help of this rate, and by noticing the mercurial column in the baromteric tube, the height to which a person has ascended may be determined. The rate at which the mercury in a barometer falls as we ascend is not uniform. However, a fall of one inch in a barometer may be taken to represent a height of about 900 feet ascended. If, for example, on the top of a mountain the barometer stands 24 inches, the height of the mountain must be taken to be about 6×900 or 5.400 feet above the sea-level.

Q. 99.—Sketch and describe fully the action of common water-pump and explain how the altitude of the place affects the height to which it will raise water.—M.U., 1884.

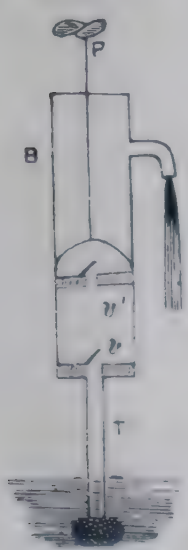

Fig. 24.

Ans.—Fig. 24 represents a water-pump. The water-pump is an instrument by means of which liquids can be raised from a lower level to a higher level. *Its various parts* are (1) a barrel (marked B) connected with the liquid below by means of a tube. A water-tight piston (P) moves up and down in the barrel. In the upper part of the barrel, there is a spout through which water escapes. There are two valves one (marked *v'*) in the piston and the other (marked *v*) in the lower part of the barrel where the tube joins it. Both the valves can open only upwards.

How the Pump works.—The action of the water-pump is as follows: when the piston is raised, a vacuum is created between the bottom of the barrel and the piston. The outside air tries to rush into it, but it does not succeed, because the valve, through which the outside air may enter, does not open that way. Therefore, the air in the tube enters it through the

valve at the bottom of the barrel, because that valve opens upwards and allows it to pass through. A part of the air in the tube having gone into the barrel, the pressure of the air inside the tube becomes less than that of the air outside. The outside air presses over the water, which rises into the tube. When the piston is lowered, the air between the piston and the bottom of the barrel is compressed. The compressed air cannot go through the lower valve, because it does not open downwards. Therefore, the compressed air opens the valve in the piston and escapes through it.

The effect of an up-and-down stroke is, thus, to send *out* a part of the air in the tube, and *raise some water into it*. A few up-and-down strokes make the water rise through the tube and enter into the barrel. *After that*, the effect of a down stroke in the water-pump is to allow the water to pass through the valve in the piston, so that the water flows out through the spout later on as the piston is raised.

'Altitude' means 'Elevation.' The higher we go, the less is the pressure of the atmosphere. Therefore, the atmosphere can sustain a longer column of water at a lower level than at a higher level. Hence, by means of a water-pump, water can be raised to a greater height at a lower level than at a higher level.

Q. 100.—(*a*) In what respects does a water-pump resemble an air-pump? (*b*) If the valves of a water-pump be made to open down instead of up, what would be the result of working the piston and attempting to use the instrument as a water-pump?—M.U., 1881.

Ans.—(*a*) *Resemblance in the parts*:—Both have a tube, valves, barrel, and piston in common.

Resemblance in action:—The positions of the valves are also common. When the pumps are worked, the air in the tube goes into the barrel in both cases. The water rises into the tube of the water-pump owing to the reduced pressure there. In the air-pump the air in the bell-jar enters into the barrel for a similar reason.

(*b*) **The effect of reversing the valves in a water-pump**:—Such a pump will not work as a water-pump. At each up-and-down stroke the outside air is forced through the water at the mouth of the tube so that bubbles of air will be seen at that place. In the downward stroke the lower valve opens and sends the air through the tube; and in the upward stroke the valve in the piston opens and the lower valve closes; and now the outside air rushes into the barrel.

Q. 101.—Explain how a pipette is filled by suction.—Lon. Mat., 1901.

Ans.—When the pipette is sucked, the air inside the tube is drawn into the mouth. The pressure of the air inside is thus removed and the pressure of the air outside being now greater presses over the liquid and it rises into the tube.

Q. 102.—"Suppose you take a bladder and weigh it first empty and, then, inflated with the air; can you by this experiment show that air has weight? Give reason for your answer."

Ans.—No. To find out the weight of the air we must take a glass globe or some other vessel with strong sides so that the size of the vessel may not change with the presence or absence of the air inside.

In this case, the bladder weighs the same in both cases. The bladder when inflated occupies a correspondingly larger volume. But its weight would be diminished by that of the air which it displaces. The air which it displaces is exactly equal to the air which it contains.

Q. 103.—What is a "*vacuum*"? Sketch and describe the parts of the instrument by means of which it can be produced.

Ans. Vacuum is the name given to the space which does not contain air or any other matter. The air-pump is the instrument whereby a vacuum can be produced. Fig. 25 illustrates a simple form of the air-pump. Its various parts are:—(1) a smooth and round metallic plate with a hole in the centre marked O in the figure and called the bed-plate; (2) *a tube* (marked T) connecting the bed-plate with the cylinder B known as (3) *the barrel* of the air-pump; (4) an air-tight piston marked (P) capable of being moved up and down the barrel; (5) two valves (marked v and v), one of which closes the tube opening into the barrel, and the other closes a hole in the piston itself. When a vacuum is required a bell-jar with a smooth edge is greased and fixed on to the bed-plate. It is called a receiver and is marked *d* in the figure.

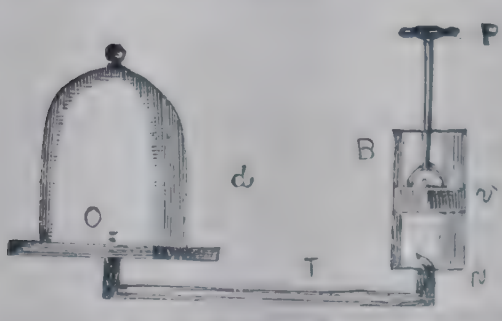

Fig. 25.

Q. 104.—Explain the terms 'exhaustion' and 'valves.' Describe the action of an air-pump showing clearly the part played by the valves in the exhaustion.

Ans.—A valve is a tightly fitting door which closes a hole and can open only one way. Figs. 26 and 27 represent two kinds of valves. The valves in the air-pump open only *away from the receiver*. Exhaustion is the word used to denote the removal of the air from a vessel by the air-pump. The *action of the air-pump* is as follows:—

(1) Raise the piston. The effect of this is to produce a vacuum between the piston and the bottom of the barrel. To occupy the empty space, the outside air tries to rush in, but cannot enter through the valve in the piston, because it opens only away from the receiver and not towards the receiver. The air from the receiver or some other vessel greased on to the bed-plate to be exhausted rushes through the tube opening the valve at the bottom of the barrel (see fig. 25). Thus, the raising of the piston transfers a part of the air in the receiver into the barrel.

(2) Now lower the piston. The effect of this is to compress the air between the piston and the bottom of the barrel. The compressed air cannot go back through the tube T, because the valve at the bottom of the barrel opens only away from the receiver, and not towards the receiver. Therefore the air escapes through the valve in the piston. Thus, the effect of raising and lowering the piston is to send out a part of the air in the receiver. If you raise the piston, and then lower it, a number of times, exhaustion may be carried on to a very great extent.

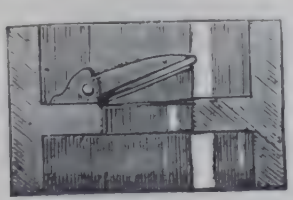

Fig. 26.

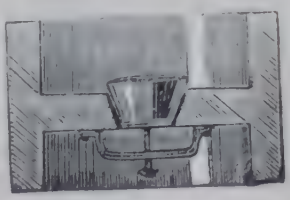

Fig. 27.

Q. 105.—Explain the terms—an up-stroke, a down-stroke, an up-and-down stroke, bed-plate, barrel and piston.

Ans.—The act of raising the piston is called an up-stroke. The act of lowering the piston is called a down-stroke. Raising and lowering the piston are together spoken of as an up-and-down stroke.

Bed-plate is the name given to the smooth and round metallic plate with a hole in the centre and connected with the barrel of the air-pump by means of the tube.

Barrel is the name given to the cylinder of the air-pump connected with the bed-plate by means of the tube.

Piston is the name given to the air-tight plug capable of being moved up and down the barrel.

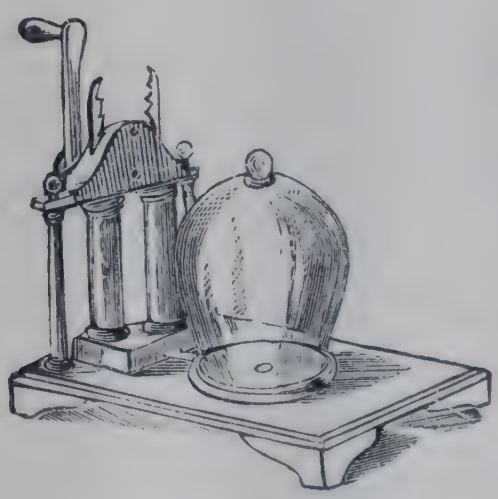

Fig. 28.

Q. 106.—What is a double-barrelled air-pump and how does it differ from the one described in Q. 103?

Ans.—The air-pump described is a single-barrelled air-pump. A double-barrelled air-pump contains two barrels. Fig. 28 represents it. Its action resembles that of the ordinary air-pump, but the exhaustion is carried on very much quicker.

Q. 107.—Is it possible to remove *all* the air from a receiver by means of an air-pump? Give reasons for your answer.

Ans.—No. An air-pump cannot remove all the air from a receiver for two reasons:—(1) For, every up-and-down stroke removes a part of the air in the bell-jar leaving the remaining air in it which fills up the whole jar again. (2) After a number of up-and-down strokes, the air in the receiver becomes so very rarefied that it becomes too feeble to lift the valve and escape. Nevertheless, a very large proportion of the air in the receiver may be removed by means of an ordinary air-pump.

Q. 108.—If, in the construction of the air-pump, the valves be made to open only towards the receiver, what would be the effect of an up-and-down stroke of such an instrument?

Ans.—The instrument will not, then, serve as an air-pump. The effect of an up-and-down stroke will be to force in the outside air into the receiver. Such an instrument goes by the name of a condensing pump. Bellows and the inflators used to inflate the bicycle tyres are constructed on this principle.

(The pupil should draw proper diagrams and describe the action in detail to show how the air enters into the receiver at every up-and-down stroke.)

Q. 109.—The receiver of an air-pump contains 100 cubic inches of air. How much of it would go out after 2 up-and-down strokes, the volume of the receiver being 100 cubic inches and the size of the barrel being 25 cubic inches?

Ans.—Raise the piston. The air in the receiver occupies the barrel also, and thus becomes 125 cubic inches.

Lower the piston. The barrelful of air, *i.e.*, 25 cubic inches of air goes out.

$\therefore$ For one up-and-down siroke $\frac{25}{125}$ or $\frac{1}{5}$ of the air in the receiver goes out.

Now there is only $1 - \frac{1}{5} = \frac{4}{5}$ of the former air in the receiver.

$\therefore$ Another up-and-down stroke removes $\frac{1}{5}$ of $\frac{4}{5} = \frac{4}{25}$ of the original

Altogether therefore $\frac{1}{5} + \frac{4}{25} = \frac{5+4}{25} = \frac{9}{25}$ of the air, *i.e.*, $\frac{9}{25} \times 100 =$

36 cubic inches of the air goes out for 2 up-and-down strokes.

Q. 110.—How can you show that the mercurial column in a barometer is supported by the pressure of the air?

Ans.—(1) Break the top of the barometer. The air enters into the tube with a hissing noise and the mercury falls down at once into the basin. (2) If you take the barometer to a place where the atmospheric pressure is not so great, the mercurial column will also become shorter proportionately.

Q. 111.—(*a*) Why is the vacuum at the top of the mercury in a barometer called the Torricellian Vacuum? (*b*) How would you prove that it is a vacuum?

Ans. (*a*) Torricelli was an Italian philosopher. It was he that proved conclusively the weight of a column of the air by means of the barometer experiment. Before his time it was thought that mercury remained in the tube, because 'Nature abhors vacuum.' But he showed that it is on account of the pressure of the air and, therefore, only a certain column of mercury remains in the tube according to the pressure of the air leaving the remaining part of the tube a vacuum. Hence it goes after his name.

(*b*) i. While the barometer tube is under the surface of mercury pass a rubber sheet under it and tie it well to the tube. Take it out carefully and invert it. The vacuum now comes under the rubber sheet, which will be seen to be pressed inwards on account of the pressure the air outside.

Fig. 29.

ii. If you break the top of the tube of a barometer the air rushes in with hissing noise and the mercurial column will go down the tube to the same level as the mercury in the basin.

Q. 112.—How does a barometer foretell weather?

Ans.—Vapour of water is lighter than air. When such vapour is present in the air, the pressure of the air becomes lessened and the column in the barometer becomes shorter. The vapour soon turns to rain. A sudden fall in a barometer, therefore, indicates rain or storm. In barometers, known as wheel barometers (fig. 29), there is an arrangement whereby the movement of mercury in the tube makes a pointer denote the changes in the weather.

Q. 113.—What would be the height of the column in a water-barometer at a place where the mercurial barometer stands 24 inches?

Ans.—Water is $13\frac{1}{2}$ times lighter than mercury.

∴ The pressure of the air can support $13\frac{1}{2}$ times more water than mercury.

But according to the sum, the atmosphere can support a column of 24 inches of mercury at that place.

∴ The column in the water-barometer $= \frac{24 \times 27}{2} \times \frac{1}{12} = 27$ ft.

Q. 114.—Why is mercury selected to fill a barometer ordinarily?—Pun. Ent., 1904.

Ans.—(1) Being the heaviest of all liquids, it stands at the least height.

(2) Being bright, it can be seen in the tube readily.

(3) It does not wet the glass and therefore moves freely in the tube.

(4) It does not escape as vapour from the basin as water does.

Q. 115.—How can you find out whether some air on the top of the column in a barometer makes it give us wrong readings?

Ans.—(1) Heat the closed part by a spirit lamp. If the column of the mercury in the tube be not affected, then you may learn that there is no air in that part. If air be present, it will expand and make the mercury in the tube go down.

(2) Close the open end with a finger and suddenly invert it. If the mercury falls quickly making a sharp noise, then too, the absence of the air may be inferred. If air be present in that part of the tube, it acts like a cushion and obstructs the mercury, so that it falls slowly without producing any noise.

Q. 116.—At a certain place the barometer stands 26 inches. What may be the greatest length of a water-pump tube at the place.

Ans.—The barometer at that place stands 26 inches. This means that the atmosphere can support a column of 26 inches of mercury. Therefore it can support a column of $\frac{26 \times 27}{2} = 351$ inches of water, *i.e.*, $29\frac{1}{4}$ ft. of water. Hence the tube of the water-pump must not exceed $29\frac{1}{4}$ ft. in order that that instrument may work.

Q. 117.—(*a*) In the above case, can water be actually raised to the height of $29\frac{1}{4}$ ft. by the water-pump? (*b*) In cases where water is to be raised from very great depths what contrivance is made?

Ans.—(*a*) No. Although the pressure of the air can support a column of $29\frac{1}{4}$ ft. water cannot be raised to that height by means of a water-pump on account of the resistance offered by the sides of the tube to the rise of water in it. The instrument can only raise water *nearly* to that height.

(*b*) If water is to be raised from greater depths, a succession of valves at certain intervals in the tube of the water-pump is arranged.

Q. 118. Describe and explain the action of the syphon. How would the working of a syphon be affected if there be a hole in the tube?

Description.—The tube which is to work as syphon is first filled with the liquid to be transferred. One end of it is then introduced into the liquid to be transferred and the other is left in the place to which the liquid is to be transferred. The liquid then continues to flow.

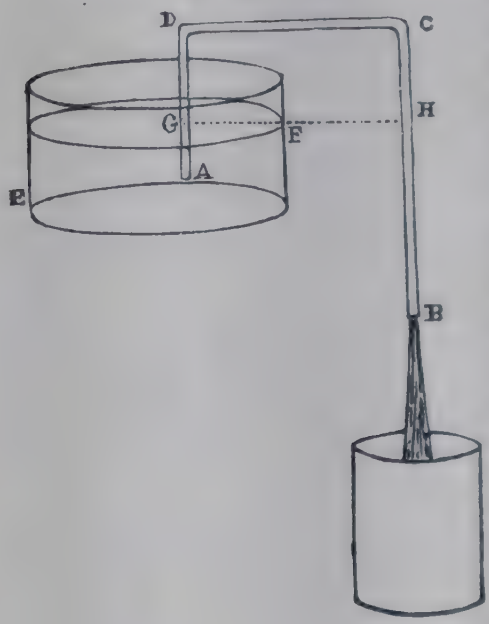

Fig. 30.

Explanation of the action.—When once started, the flow continues on account of the pressure of the atmosphere on the surface of the liquid. In fig. 30 suppose GD is 10 ft. and CB 20 ft. The atmosphere can support a column of about 34 ft. of water. But at G it has already supported 10 ft. and therefore it can support 24 ft. more. But at B it can support only 14 ft. more, Thus the pressure at G being greater than the pressure at B, the flow continues.

The working of the syphon is affected in different ways according to the position of the hole.

If the hole be in any part of the tube below the level of the liquid, (below H in fig. 30) the flow continues, but will not be so rapid as before. If the hole be in any part of the tube above the surface of the liquid, then the flow stops at once. If the hole be at C, for example, then DC will be the outer leg practically and its end C being above the level of the liquid in the vessel, the flow stops at once.

Q. 119. It is required to transfer a liquid 4 times as heavy as water by means of a syphon at a place where the barometer stands 24 inches. Calculate the greatest height of the arm within the liquid.

Ans.—In that place the atmosphere can support 24 inches of mercury.

∴ It can support $13\frac{1}{2} \times 24$ inches of water. (because water is $13\frac{1}{2}$ times lighter than mercury).

∴ A liquid 4 times heavier than water can be supported only to $\frac{1}{4}$ of the water column, *i.e.*, $\frac{1}{4} \times 13\frac{1}{2} \times 25 = 81$ inches.

∴ The greatest height of the arm in the liquid must not exceed 81 inches.

Q. 120.—What is buoyancy? Give three instances illustrating the buoyancy of the air.

Ans.—Buoyancy is the name given to the upward pressure in gases and liquids. (1) Soap bubbles filled with hydrogen rise in the air; (2) a balloon ascends high up; (3) if a tumbler, full of water, is covered over with a sheet of paper and carefully inverted, the water in the tumbler remains in it without falling down, on account of the upward pressure of the air (The use of the paper is to present an even surface to the action of the air.) These three instances show that the air exerts upward pressure.

Q. 121.—A piece of charcoal is suspended from one arm of a balance and is exactly counterpoised by a piece of lead at the extremity of the opposite arm. If the balance be now placed under the receiver of an air-pump and the air exhausted, how will the balance be affected?—M.U.

Ans.—Owing to the buoyancy of the air, substances weighed in the air lose a part of their weight equal to the weight of an equal volume of the air. The bigger the substance, the greater the weight lost thereby. Here, in the given case, the piece of charcoal weighing the same as the piece of lead, must be much larger than that piece of lead. Both of these balance in the air. But when taken into a place where there is no air, they are not buoyed up and, so, gain *their lost weights*. On account of its larger bulk, charcoal lost more in the air than the piece of lead, and this it gains. In the vacuum, therefore, the charcoal does not balance the lead, but weighs more than the piece of lead.

Q. 122.—A piece of lead is fastened to a bladder containing air so that it just sinks to the bottom of a vessel containing water. If the vessel is now placed under the receiver of an air-pump and the air exhausted, state and explain what will happen.—M.U., 1891.

Ans.—The whole thing just sinks, because it is equal in weight to that of the same volume of water. When the vessel is placed under the receiver and the air exhausted, the air in the bladder expands and makes the bladder bigger. Now, the weight of the bladder remains the same as before, but the volume becomes larger. The bladder, thus, becomes lighter than an equal volume of water and, hence, it floats.

Q. 123.—Explain clearly why an ordinary glass bottle will float in water, while a solid glass ball will sink. M.U., 1895.

Ans.—A substance sinks in a liquid, when it is heavier than an equal volume of the liquid. Glass is heavier than an equal volume of water and hence, a solid glass ball sinks in water.

A substance floats on a liquid, when it is lighter than an equal volume of the liquid. In the given case, although glass is heavier than water, the bottle has air in it, which is many times lighter than an equal volume of water. The glass bottle, together with the air in it, is lighter than an equal volume of water and, hence, it floats.

Q. 124.—Define specific gravity, and arrange the following in the order of their specific gravity:—Iron, water, air, mercury, alochol, gold, salt water, hydrogen.—M.U., 1882.

Ans.—The specific gravity of a body is the number, which tells us how many times the given substance is heavier than an equal volume of the standard substance—water for solids and liquids, and the air for gases.

Order:—Gold, mercury, iron, salt water, water, alcohol, hydrogen.

Q. 125.—How would you test the purity of an irregular lump of gold by means of the balance? Give reasons for the method which you adopt.—M.U., 1889.

Ans.—Put the lump in a vessel *full* of water. Then water of an equal volume overflows. Collect this water and weigh it.

Find out the weight of the lump. If the weight of gold be 19 times the weight of its own volume of water, then the lump may be taken to be pure gold. Otherwise not. Because, it has been ascertained that only pure gold is 19 times heavier than its own volume of water. If the gold is not pure, then it will be heavier or lighter than 19 times its own volume of water.

Q. 126. What is the principle of Archimedes? How would you demonstrate that, if you are given (i) a solid cylinder fitting exactly into a hollow socket, (ii) an elastic cord, (iii) a jar, and (iv) water.—M.U., 1890.

Ans. "A body immersed in a liquid loses a weight equal to the weight of the displaced liquid, *i.e.*, an equal volume of the liquid." Attach the socket and the cylinder to the scale pan of a balance, so that the cylinder may be below the socket. Counterpoise these by means of weights in the other scale pan. Then bring the jar with water below the cylinder, so that the cylinder may be completely immersed in it. The

cylinder will appear to lose weight. Now fill the socket with water and the weight will be restored. This shows that when a substance is weighed in water it loses the weight of an equal volume of water.

Q. 127. A vessel quite full of water, and suspended from one arm of a balance, is counterpoised by weights placed in scale-pan of the other arm. If a stone, 3 cubic inches in bulk, be now hung in the water by a string, but so as not to touch the vessel, how would the balance be affected?—M.U., 1884.

Ans.—The stone takes the place of three cubic inches of water, and this water will flow out. A part of the weight of the stone equal to that of 3 cubic inches of water is supported by the water, and the remaining weight of the stone is supported by the hand. As the pressure in the vessel of water has not been increased on account of the presence of the stone, the balance remains unaffected.

Q. 128.—You are given two test tubes and a common wooden pencil. The test tubes are about half-filled with water and oil, respectively. Explain how you may roughly find the specific gravity of the oil with this simple apparatus.—M.U., 1893.

Ans.—The weight of a floating body is equal to the weight of the liquid displaced by it. Put the pencil into the water. Note how far the water rises. Suppose the water displaced is one cubic inch. Then put the pencil into the oil. Suppose the oil displaced is $1\frac{1}{2}$ cubic inches. Therefore the weight of the pencil is equal to the weight of $1\frac{1}{2}$ cubic inches of the oil. Hence $1\frac{1}{2}$ cubic inches of the oil weigh the same as 1 cubic inch of the water. Therefore *one* of oil is equal to $\frac{2}{3}$ of water, *i.e.*, specific gravity of the oil is $\frac{2}{3}$.

Q. 129. How would you proceed to determine the specific gravity of (1) Kerosine Oil, (2) of Common Salt.

Pun. Ent., 1903.

Ans. (1) *Kerosine Oil.* I would take a flask and find out its weight first. After filling it with water, I would weigh it again and subtract from this weight the weight of the flask. This gives me the weight of the water inside. Then, after throwing out the water, I would fill the flask with kerosine oil *to the same extent*, and weigh it again. From this weight, I would subtract the weight of the flask and, thus, obtain the weight of an exactly the same volume of kerosine oil. By dividing this weight by the weight of the water obtained above, the specific gravity of the kerosine oil could be determined.

(2) *Common Salt.*—I would determine the weight of this substance first. Then I would weigh it in kerosine oil (or some other oil in which the salt does not dissolve and the specific gravity of which has been already determined). I would note the loss of weight. This loss, which the salt sustains in kerosine oil, is the weight of an equal volume of kerosine oil. As I know how many times kerosine oil is lighter than an equal volume of water, I can find out the weight of an equal volume of water. Then dividing the weight of the salt by the weight of an equal volume of water, I could determine the specific gravity of salt.

Q. 130.—A block of stone weighing 156 tons in air, weighs 78 tons in a liquid whose sp. gr. is 3. Find out the cubical contents of the stone. [One cubic foot of water weighs 1,000 oz.]

Ans.—One cubic foot of water weighs 1,000 oz.

$\therefore$ one cubic foot of the liquid weighs 3,000 oz.

The stone weighs 156 tons in air; and in the liquid it weighs 78 tons.

$\therefore$ An equal volume of the liquid weighs 78 tons.

3,000 oz. of the liquid occupy 1 c. ft.

$$\therefore 78 \text{ tons} \quad . \quad . \quad . \quad . \quad . \quad \frac{1}{3{,}000} \times 78 \times 20 \times 112 \times 16 = 931{\cdot}8 \text{ c. ft.}$$

Q. 131.—A wooden block weighing 4 oz. hangs by a cord from one end of the beam of a balance, and an iron 4 oz. weight from the other end. Two tumblers, full of water, are now brought under the wooden block and the iron weight and raised up at the same time. What will be the effect on the balance? Show clearly by a figure.—M. U., 1904.

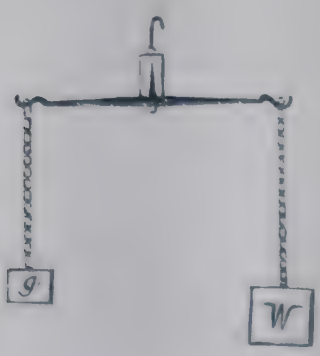

Fig. 31.

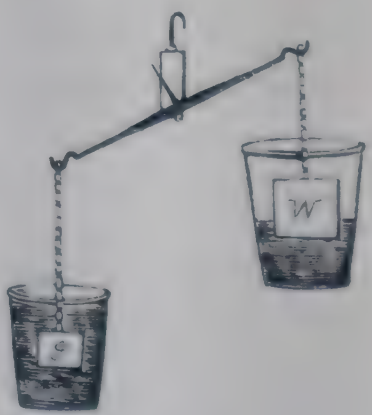

Fig. 32.

Ans. Since the iron and the wood are of equal weight, the beam rests horizontally as in fig. 31. Wood being lighter than iron, bulk for bulk, 4-oz. iron weight is much smaller in bulk than a 4-oz. wooden block. When a body is put into water, it is buoyed up with a force equal to the weight of the same volume of the liquid. Hence, the weight lost by the wooden block is not the same as that lost by the iron.

Consequently, as the tumblers are raised each mass begins to lose weight, as it gets into water. The beam of the balance continues to remain horizontal, until the weight of the water displaced by the part of wood that is immersed in water, is just equal to the weight of water displaced by iron.

If the tumblers are raised further so as to force more of the wood under water, the upward pressure on the wood will be greater and the beam of the balance will be tilted up at the end where the wooden block has been hung as shown in fig. 32.

Q. 132.—A substance weighs in alcohol 60 grains and in water 50 grains. Find out the sp. gr. and the weight of the substance (sp. gr. of alcohol = ·8).—M. U., 1900.

Ans. Let **X** grains be the weight of the substance. In alcohol, it weighs 60 grains. Since, by the principle of Archimedes, a substance weighed in a liquid loses a weight equal to the weight of the same volume of the liquid, an equal volume of alcohol weighs **X**—60 grains.

In water it weighs 50 grains.

∴ An equal volume of water weighs **X**—50 grains.

But alcohol is ·8 times heavier, bulk for bulk, than water.

$$\therefore \mathbf{X} - 60 = \tfrac{4}{5}(\mathbf{X} - 50). \quad \therefore \mathbf{X} = 100 \text{ grains.}$$

The substance weighs 100 grains.

In water 50 grains. ∴ An equal volume of water is 50 grains.

$$\therefore \text{ the sp. gr.} = \tfrac{100}{50} = \mathbf{2\ Ans.}$$

Q. 133.—The sp. gr. of alcohol is ·8. A substance put into a vessel full of alcohol makes 25 lbs. of it overflow. Calculate the volume of the substance, if 1 cubic foot of water weighs 1,000 oz.

Ans.—1 c. ft. of water weighs 1,000 oz.

∴ 1 c. ft. of alcohol weighs 1,000 × ·8 = 800 oz.

When the substance is put into alcohol, an equal volume of alcohol is displaced. 800 oz. of alcohol has the volume of 1 c. ft.

$\therefore$ 25×16 oz. of alcohol has the volume of $\frac{1}{800} \times 400 = \frac{1}{2}$ c. ft.

$\therefore$ The volume of the substance is half a cubic foot.

Q. 134.—Explain, and illustrate, how you would find out the specific gravity of a liquid with the help of a solid which is insoluble in the liquid as well as in water, and which sinks in both.

Ans.—The weight of the solid will be ascertained first. Suppose it weighs 12 oz. Then it will be weighed in water. It weighs less, say 6 oz.

Since, by the principle of Archimedes, a substance weighed in a liquid loses a weight of an equal volume of the liquid.

the weight of an equal volume of the water . . . . 6 oz.

Next, it will be weighed in the given liquid; it weighs, say 7 oz.

$\therefore$ the weight of an equal volume of the liquid is 5 oz.

$\therefore$ the sp. gr. of the liquid $= \frac{5}{6} =$ **·83 Ans.**

Q. 135.—You are given a solid that floats in water as well as in a given liquid. Explain, and illustrate, how the Sp. Gr. of the liquid may be ascertained.

Ans.—The solid is to be put into the given liquid, and then into water. The parts immersed in the liquids are to be observed. From this the specific gravity of the liquid may be ascertained.

A floating body displaces a liquid *which is equal to the weight* of the body itself. Therefore, the *liquid* displaced when the floating body is put into it and the *water* displaced when the floating body is put into it, are equal in weight. If the displaced liquid and the displaced water have the same volume, then both of them do not differ in specific gravity. If the displaced liquid is larger in bulk than the displaced water, then it is lighter than water, bulk for bulk. If the displaced liquid is smaller in volume than the displaced water, then the liquid is denser than water. So, by comparing the volumes of the displaced liquid and the displaced water, the specific gravity of the liquid may be determined.

Illustration.—Suppose a block of wood when floating in water makes one cubic foot of water overflow. Put the same block of wood in another liquid. Suppose it floats and makes three cubic feet of the liquid overflow.

Since a floating body displaces liquid equal to its own weight,
three cubic feet of the liquid = to one cubic foot of water in weight.
∴ the liquid is lighter than water;
∴ the specific gravity of the liquid is $\frac{1}{3}$. *Cf.* Q. 138.

Q. 136. 1 oz. of wood, together with 1 oz. of lead, weighs half an ounce in water. The Sp. Gr. of lead is 11. Find that of the wood.

Sol.—(1 oz., wood + 1 oz. lead) = 2 oz. weight in water $\frac{1}{2}$ oz.
∴ an equal volume of water weighs $2 - \frac{1}{2} = 1\frac{1}{2}$ oz.

The weight of water equal, in volume, to 1 oz. of lead is $\frac{1}{11}$ oz.

∴ the weight of water equal, in volume, to 1 oz. of wood is $1\frac{1}{2} - \frac{1}{11} = \frac{31}{22}$
∴ the sp. gr. of the wood = $\frac{22}{31}$ = **·7 Ans.**

Q. 137.—How may the specific gravity of a body lighter than water be determined?—Pun. Ent., 1902.

Ans.—A vessel containing water may be taken and the lighter body may be put into that water. The body floats. Then, the part under water must be noted. Then, the specific gravity of the body will be the same as the ratio of the *part under water* to the *whole* of the body.

For, a floating body displaces a liquid equal to the weight of the body itself. Therefore the weight of the whole body is the same as the weight of water of the same volume as the part of body immersed. This weight divided by the weight of the same volume of water as that of the floating body, gives the specific gravity of the solid body.

Consequently, the specific gravity of a floating body can be found out by calculating what part of it remains under water, when put in it. Suppose for example a block of wood is put on water and it floats with three-fourths of it above water. Then, its specific gravity is ·25.

Q. 138.—A cylinder of wood 40 inches in height and a cylinder of iron 1 inch long are united so as to form a uniform cylinder of 41 inches. The whole floats in a liquid with 1 inch of it above the surface of the liquid. Calculate the specific gravity of the wood—the specific gravity of iron is 7·8; and, of the liquid ·5.

Sol.—41 inches of the cylinder are equal in weight to 40 inches of the liquid. [Because a floating body displaces a liquid equal to the *weight*

of the whole body. Here the body is 41 inches long and it has displaced 40 inches of the liquid].

The liquid is half as heavy as water, for its sp. gr. is ·5.

Hence, 40 inches of the liquid has the same weight as 20 inches of water.

∴ 41 inches of the body has the same weight as 20 of water.

But of these 41 inches 1 inch is iron, and 1 inch of iron has the same weight as 7·8 inches of water.

∴ 40 inches of wood weighs the same as 20—7·8 = 12·4 of water.

∴ Sp. Gr. of wood $= \frac{12{\cdot}4}{40} =$ **·31 Ans.**

Q. 139.—A piece of wood floats in water contained in a cylindrical jar. When a piece of lead is dropped into the water the surface level rises half an inch; and when the lead and the wood are both taken out the surface level falls $5\frac{3}{4}$ inches. When the lead is attached to the wood so that when placed in the water they sink together, the surface level rises $6\frac{3}{4}$ inches. Find the specific gravity of the wood.

Sol.—Since water in the jar rises $\frac{1}{2}$ an inch, when lead is dropped, the volume of the lead = the volume of water in $\frac{1}{2}$ inch of the jar.

When the lead so dropped and the wood are taken away, the level of the water falls by $5\frac{3}{4}$ inches.

∴ the volume of the lead and the volume of *the part of wood in water* $= 5\frac{3}{4}$.

∴ the volume of the part of wood alone in water $= 5\frac{3}{4} - \frac{1}{2} = 5\frac{1}{4}$ in.

Since, when lead and wood are together dropped in the jar, the water rises by 6·75 inches, the volume of lead and wood $= 6\frac{3}{4}$ in.

The volume of wood alone $= 6\frac{3}{4} - \frac{1}{2} = 6\frac{1}{4}$ in.

Now, the volume of the wood $= 6\frac{1}{4}$ in.

When put in water $5\frac{1}{4}$ in. of it will be within the water.

∴ $6\frac{1}{4}$ in. of wood weigh the same as $5\frac{1}{4}$ of water.

∴ Sp. Gr. of wood $= \frac{5\frac{1}{4}}{6\frac{1}{4}} =$ **·84 Ans.**

Q. 140.—To the right hand scale pan of a hydrostatic balance is attached a socket and a cylinder of teakwood which

fits into the socket exactly. These are balanced in the air. (1) Explain what happens when a vessel of water is brought under the cylinder, so that it may be in the water. (2) How much weight must be added to the right hand scale pan to restore the equilibrium? (3) If you are not to add any weight, how far must the socket be filled with water to restore the equilibrium?

Ans. (1) The beam of the balance will be tilted and the teakwood cylinder goes up. (Read the Qn. 131.)

(2) Teakwood being lighter, bulk for bulk, than water, appears weightless when in water. Therefore, to restore equilibrium weights equal to that of the teakwood cylinder must be placed in the scale pan to which the cylinder is attached.

(3) The socket need not be filled with water; if so, it becomes too heavy. The socket must be filled only so far that the weight of the water may be equal to that of the wooden cylinder.

Q. 141.—What weight of brass (sp. gr. 8·2) must be *attached* to 1 c. ft. of cork (sp. gr. 0·25) in order that the cork as well as brass may just sink in water? [1 c. ft. of water weighs 1,000 oz.]. *Cf.* Qn. 162.

Sol. 1 c. ft. of cork sinks in water, when it is at least as heavy as 1 c. ft. of water.

1 c. ft. of water weighs 1.000 oz. ∴ 1 c. ft. of cork ,, 250 oz.

∴ the force needed to make 1 c. ft. of cork sink in water = 1.000—250 =750 oz.

This force must be applied by attaching brass to the cork. But the brass also is buoyed up; and 8·2 oz. of brass weighs only 7·2 oz. in water.

Hence, to exert a pressure of 7·2 oz. on the cork, a brass weight of 8·2 oz. must be attached to it.

∴ to exert a pressure of 750 oz. . . . . $\frac{82}{72} \times 750 =$ 854·16 oz. = 53·38 lbs. **Ans.**

Cf. Qns. 141 and 142.

Q. 142.—What weight of brass must be put upon one pound of cork so that the cork may float with its surface in the same level as that of the water in which it is placed.

Sol.—The given cork weighs 1 lb. An equal volume of water weighs 4 lbs.

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In order that a solid may sink in a liquid, it must weigh at least as much as an equal volume of that liquid.

Therefore, on the cork must be placed, a brass weight of 4 - 1=**3 lbs.**

Q. 143.—A floating body has 6 feet of its length outside a liquid. Find out its full length. [The liquid is three times heavier than the solid, bulk for bulk.]

Sol.—The liquid is three times heavier than the solid, bulk for bulk.

∴ A certain volume of the solid weighs only $\frac{1}{3}$ of an equal volume of the liquid.

Hence when the solid is put into the liquid $\frac{1}{3}$ will be within and $\frac{2}{3}$ outside the liquid.

Now, $\frac{2}{3}$ of the body is 6 ft. ∴ the whole body is 9 ft. **Ans.**

Q. 144.—The Sp. Gr. of iron is 7·8; of mercury is 13·5. What force must be exerted to force half a pound of iron under mercury?

Sol.—In order that a solid may sink in a liquid, it must weigh at least as much as an equal volume of that liquid.

Now iron weighs $\frac{1}{2}$ lb. An equal volume of water weighs $\frac{1}{2} \times \frac{1}{7{\cdot}8}$ lb.

∴ An equal volume of mercury weighs $\frac{1}{2 \times 7{\cdot}8} \times 13{\cdot}5 = \frac{135}{156}$ lbs.

∴ The force necessary to make half a pound of iron to sink in mercury $= \frac{135}{156} - \frac{1}{2} = \frac{57}{156} = \frac{19}{52}$ lbs. **Ans.**

Q. 145.—Explain: "the specific gravity of cork is ·25." Calculate (1) the part that remains above water, when 4 c. ft. of cork is placed in water; (2) the part that remains above mercury when the same is placed in mercury (sp. gr. 13·5).

Ans. Cork weighs only one-fourth as much as an equal volume of water,

[*i.e.*, if a certain volume of water weighs one, an equal volume of cork weighs only one-fourth.]

(1) A floating body displaces a liquid equal to its own weight. Four c. ft. of cork have the same weight as 1 c. ft. of water. Therefore 1 c. ft. of water will be displaced by the cork. Hence, 3 c. ft. of the cork will be outside the water, and 1 c. ft. inside the water.

(2) 4 c. ft. of cork have the same weight as 1 c. ft. of water; and 1 c. ft. of water has the same weight as $\frac{1}{13{\cdot}5} = \frac{2}{27}$ c. ft. of mercury.

$\therefore$ 4 c. ft. of cork displaces only $\frac{2}{27}$ c. ft. of mercury. Hence $3\frac{25}{27}$ c. ft. of the cork will be above mercury, and $\frac{2}{27}$ c. ft. within.

Q. 146.—The sp. gr. of ice is ·9; of salt water, 1·025. Calculate the volume of an iceberg which floats with 100 c. yds. of it above the surface of water.

Sol.—

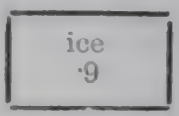

Fig. 33.

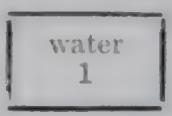

Fig. 34.

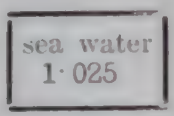

Fig. 35.

Figs. 33, 34 and 35 enable you to see that if a certain volume of water weigh *one*, an equal volume of ice weighs ·9, and an equal volume of sea water 1·025.

$\therefore$ ice weighs $\frac{\cdot 9}{1{\cdot}025}$ of the same volume of sea water.

A floating body displaces a quantity of the liquid equal to its own weight. Hence, ice in the sea water displaces $\frac{\cdot 9}{1{\cdot}025}$ of its own volume of water.

$\therefore$ $\frac{\cdot 9}{1{\cdot}025}$ of the ice will be within water and the remainder $\frac{\cdot 125}{1{\cdot}025}$ will be outside the water

Now $\frac{\cdot 125}{1{\cdot}025}$ or $\frac{125}{1025}$ of the iceberg = 100 c. yds.

$\therefore$ the whole volume $\frac{100 \times 1025}{125} =$ **820 c. yds.**

Q. 147.—Glycerine rises in a barometer tube to a height of 26 ft., when mercury stands at 30 inches. The specific gravity of mercury is 13·6; find that of glycerine.—Pun. Ent., 1902.

Ans.— The atmosphere can support a column of 30 inches of mercury or 26 ft. of glycerine.

Therefore a column of mercury 30 inches long has the same weight as that of 26 feet of glycerine.

But 30 inches column of mercury has the same weight as that of $30 \times 13{\cdot}6 = 408$ inches of water.

$\therefore$ 408 inches of water weighs the same as $26 \times 12 = 312$ inches of glycerine.

$\therefore$ the specific gravity of glycerine $= \frac{4}{3}\frac{0}{1}\frac{8}{2} =$ **1·3 Ans.**

Q. 148.—A dish is quite full of mercury. If a 4-lb. iron weight is now laid on the surface of the mercury, how many cubic inches of mercury will overflow? Given that 1 c. ft. of water weighs 1,000 oz.—M.U., 1890.

Ans.—A floating body displaces a liquid equal to the weight of the body itself.

$\therefore$ The mercury displaced is 4 lbs. or 64 oz.

1 c. ft. of water weighs 1.000 oz. $\therefore$ 1 c. ft. of mercury weighs 13.500 oz.

$\therefore$ 13,500 oz. of mercury occupies 1 c. ft., (*i.e.*, 1,728 c. in.

$\therefore$ 64 oz. of mercury occupies $\frac{1}{1}\frac{7}{3}\frac{2}{5}\frac{8}{0}\frac{}{0} \times 64$ or $8\frac{2}{1}\frac{4}{2}\frac{}{5}$ c. in. **Ans.**

Q. 149.—I suspend by a thread an iron 1-pound weight (specific gravity 7) from one end of the beam of a balance so as to be immersed in water; what weight of lead (specific gravity 11) must I similarly suspend from the other end of the beam so as to bring the beam to the horizontal position? —M.U., 1881.

Sol.—7 lbs. of iron in air weighs 6 lbs. in water.

$\therefore$ 1 lb. of iron in air weighs $\frac{6}{7}$ lbs. in water.

The question now is, what weight of lead immersed in water and suspended from the other end of the beam produces a force of $\frac{6}{7}$ lbs?

11 lbs. of lead in air weighs 10 lbs. in water. Hence, to produce a force of 10 lbs. a weight of 11 lbs. of lead must be suspended.

$\therefore$ „ „ $\frac{6}{7}$ „ „ $\frac{1}{1}\frac{1}{0} \times \frac{6}{7} = \frac{5}{3}\frac{3}{5}$ lbs. **Ans.**

Q. 150.—A piece of cork 10 lbs. in weight is floating in a vessel of water; if the cork, bulk for bulk, is a quarter as heavy as water, what weight will make it just begin to sink? State clearly the physical principles involved—M.U., 1884.

Ans.—A body sinks in water, when it is at least as heavy as an equal volume of the water. Cork being $\frac{1}{4}$ as heavy as water, an equal volume of water weighs 40 lbs.

The cork already weighs 10 lbs. The weight necessary to make it sink is $40 - 10 = 30$ lbs.

Q. 151.—Find the force in pounds weight needed to press (*a*) 1 c. ft. of cork (specific gravity ·25) under water, (*b*) 1 c. ft. of iron (specific gravity 7) under mercury (specific gravity 13) having given that 1 c. ft. of water weighs $62\frac{1}{2}$ lbs.—M.U., 1887.

Sol. In order that a body may sink in a liquid, it must be at least as heavy as an equal volume of the liquid.

1 c. ft. of water weighs $62\frac{1}{2}$ lbs.

1 c. ft. of cork weighs $\frac{125}{2} \times \frac{1}{4} = \frac{125}{8} = 15\frac{5}{8}$ lbs.

1 c. ft. of mercury weighs $62\frac{1}{2} \times 13$ lbs.

1 c. ft. of iron weighs $62\frac{1}{2} \times 7$ lbs.

(*a*) The force necessary to press 1 c. ft. of cork under water, is $62\frac{1}{2} - 15\frac{5}{8}$ lbs. $= 46\frac{7}{8}$ lbs.

(*b*) The force necessary to press 1 c. ft. of iron under mercury, is $(62\frac{1}{2} \times 13) - (62\frac{1}{2} \times 7) = 375$ lbs. **Ans.**

Q. 152.—(*a*) I have to find the specific gravity of a lump of gold-bearing quartz and am provided with a suitable balance, but have only half annas and pies for weights. I find the stone weighs in air 12 annas and 10 pies, but in water 11 annas and 8 pies. What is its specific gravity? (*b*) If it had been a lump of ordinary quartz of specific gravity 2·8, what should it have weighed in water? Explain clearly the steps of your answer.—M.U., 1894.

Sol.—(*a*) The stone weighs in air 154 pies.

The stone weighs in water 140 pies.

∴ An equal volume of water is 14 pies, because a body weighed in a liquid loses a weight of an equal volume of that liquid.

∴ The sp. gr. of the stone $= \frac{154}{14} = 11$ Ans.

(*b*) Quartz weighing $2\frac{1}{5}$ in air weighs in water $1\frac{4}{5}$.

∴ Quartz weighing 154 pies in air . . . . $\frac{6}{5} \times \frac{5}{14} \times 154 = 99$ pies. **Ans.**

(The Sp. Gr. of quartz is $2\frac{1}{5}$. This means, it is $2\frac{1}{5}$ times heavier than water, bulk for bulk. A body weighed in a liquid loses a weight of an equal volume of that liquid. So quartz weighing $2\frac{4}{5}$ pies loses, when weighed in water, the weight of one pie.)

Q. 153.—A substance which weighs 1,000 grains in air and appears to have no weight at all in water, appears to weigh 206 grains in alcohol. Find the weight of its volume of alcohol and of water, and hence deduce the specific gravity of alcohol.—M.U., 1895.

Sol.—A substance which appears to have no weight in water must be at least as light as an equal volume of water. Therefore,

An equal volume of water = 1,000 grs.

An equal volume of alcohol weighs = 1.000 − 206 = 794 grs., because the body weighs in air 1.000 grs. and in alcohol 206 grs.

∴ the specific gravity of alcohol = $\frac{794}{1000}$ = **·794.**

Q. 154.—State the principle of Archimedes. A body weighs 40 lbs. in a liquid whose density, relatively to water, is 2; and weighs 45 lbs. in water. What is its volume? What is its density? What is its mass? *N.B.* 1 cubic inch of water weighs ·036 pounds.—L.U., 1899.

Sol.—(i) The weight of the body in air − the loss of weight in water = 45 lbs.

Weight of the body in air *minus* the loss of weight in the liquid = 40 lbs.

But the sp. gr. of the liquid is 2.

(ii) ∴ Weight of the body in air *minus* (2 × the loss of weight in water) = 40 lbs. Subtract (ii) from (i).

∴ Loss of weight in water = 5 pounds.

∴ *The weight of the body* = 45 + 5 = 50 lbs. **Ans.**

Hence, its specific gravity = $\frac{50}{5}$ = 10. **Ans.**

Its *volume*: 1 c. in. of water weighs ·036 lb. ∴ 1 c. in. of this thing weighs ·036 × 10 lb. = ·36 lb.

$\frac{36}{1000} = \frac{9}{250}$ lbs. of the substance occupies 1 c. in.

∴ 50 lbs. of the substance . . . . . $\frac{250}{9} \times 50 = 138\frac{8}{9}$ c. in. **Ans.**

Q. 155. A substance weighing 10 lbs. in air, weighs only 7 lbs. in a liquid whose specific gravity is ·75. Find out the specific gravity of the substance.

The weight of the substance . . . . . 10 lbs.

Its weight in the liquid . . . . . 7 lbs.

∴ (10—7) or 3 lbs. is the weight of its own volume of the liquid.

∴ An equal volume of the liquid weighs 3 lbs.

∴ An equal volume of water weighs 4 lbs., because the specific gravity of the liquid is $\frac{3}{4}$.

∴ The specific gravity of the body $= \frac{10}{4} = 2{\cdot}5$.

Q. 156. A solid weighs 30 ounces. Its weight in water is 20, and in another liquid 15. Find out the specific gravity of the liquid.

Sol.—Its weight in air is 30 oz.; in water 20 oz.

∴ An equal volume of water weighs 10 oz.

For the same reason an equal volume of the liquid weighs 30 − 15 or 15 oz.

∴ Specific gravity of the liquid $= \frac{15}{10} = 1{\cdot}5$.

Q. 157. A body (specific gravity 7·5) weighs in air 7 lbs. and in another liquid 6 lbs. Determine the specific gravity of the *liquid.*

Sol.—Its specific gravity is 7·5, *i.e.*, if a certain volume of water weighs 1, an equal volume of the substance weighs 7·5.

When weighed in water, therefore, this substance loses a weight equal to that of its own volume of water, *i.e.*, $\frac{1}{7{\cdot}5}$ or $\frac{2}{15}$ of its weight.

∴ The weight of an equal volume of water is $\frac{2}{15} \times 7$ lbs.

In the given liquid it loses 7—6 or 1 lb.

∴ The weight of the same volume of the liquid=1 lb.

∴ Specific gravity of the liquid $= \frac{1}{\frac{2}{15} \times 7} = \frac{15}{14} = 1{\cdot}07$.

Q. 158. A body floats in water with $\frac{2}{3}$ of it above the surface of water. Find the specific gravity of the body.

Sol. Suppose the weight of *an equal volume* of water to be x lbs.

Since a floating body displaces a liquid of the same weight, and in this case the displaced liquid is only $\frac{1}{3}$ of its volume,

∴ the weight of the body is . . . . . $\frac{1}{3}x$ lbs.

And the same volume of water weighs x lbs.

∴ its specific gravity $= \frac{\frac{1}{3}x}{x} = \frac{1}{3}$ **Ans.**

Q. 159.—A substance when plunged in a vessel full of water makes 10 grammes of it run over. When placed in a vessel full of mercury it floats displacing 78 grammes of it. Required the weight, volume and comparative density of the substance.

[*N.B.*—1 cubic centimeter of water weighs 1 gramme.]

Ans. Since a body immersed in a liquid displaces the same volume of the liquid, it occupies the space occupied by 10 grammes of water.

1 gramme of water occupies a space of 1 c. c.

∴ The volume of the body is 10 c.c.

Since a floating body displaces an amount of the liquid equal to its own weight, and since the weight of mercury displaced in this case is 78 grammes ;

∴ The weight of the body is 78 grammes.

Since the weight of the body is 78 grammes and that of an equal volume of water 10 grams., its specific gravity $= \frac{78}{10} = 7{\cdot}8$.

Q. 160.—A block of iron (sp. gr. 7) 140 lbs. in weight is suspended under water by a rope. Calculate the tension on the rope.

Sol.—7 lbs. of the body weigh in water 6 lbs.

∴ 140 lbs. of the body weighs in water 120 lbs.

∴ The tension on the rope, *i.e.*, the force with which the rope is stretched, is the weight of the block under water=120 lbs.

Q. 161. A block of platinum, sp. gr. 22, weighs 33 lbs. What will be its weight under mercury (sp. gr. $13\frac{1}{2}$) ?

Sol.—A body weighed in a liquid loses a weight of an equal volume of that liquid. The Sp. Gr. of platinum is 22, *i.e.*, if a certain volume of water weighs 1 lb., an equal volume of platinum weighs 22 lbs.

∴ 22 lbs. of platinum loses when weighed in water 1 lb.

∴ 33 lbs. of platinum loses when weighed in water $\frac{1}{22} \times 33 = 1\frac{1}{2}$ lbs.

∴ an equal volume of water weighs $1\frac{1}{2}$ lbs.

∴ an equal volume of mercury weighs $1\frac{1}{2} \times 13\frac{1}{2} = 20\frac{1}{4}$ lbs.

∴ the weight under mercury would be $33 - 20\frac{1}{4} = 12\frac{3}{4}$ lbs.

Q. 162.—A piece of cork weighing 25 lbs. floats in salt water (sp. gr. 1·025). Calculate what weight of brass (sp. gr. 8·2) must be attached to the cork (sp. gr. ·25), so that the brass and cork may float wholly immersed. (*Cf.* Q. 141.)

Sol.—In order that a body may sink in water, it must be at least as heavy as an equal volume of the liquid.

If a certain volume of cork weighs ·25 lbs., an equal volume of salt water weigh 1·025 lbs.

$\therefore$ „ . . . . . „ 25 lbs. . . . . $\frac{1{\cdot}025}{{\cdot}25} \times 25 = 102\frac{1}{2}$ lbs.

$\therefore$ In order that the cork may sink, a force of $102\frac{1}{2} - 25$ lbs. $= 77\frac{1}{2}$ lbs. must be exerted. This is required to be done by attaching brass to the cork.

8·2 lbs. of brass weigh in salt water . . . . $8{\cdot}2 - 1{\cdot}025 = 7{\cdot}175$ lbs.

$\therefore$ to exert a force of 7·175 lbs. on the cork, brass weighing 8·2 lbs. must be attached.

$\therefore 77\frac{1}{2}$ . . . . . $\frac{8{\cdot}2}{7{\cdot}175} \times 77{\cdot}5 = 88\frac{4}{7}$ lbs.

UNANSWERED QUESTIONS.

Q. 163.—State the facts that you learn when two similar beams bend differently under different weights as shown in figures 36 and 37.

Fig. 36.

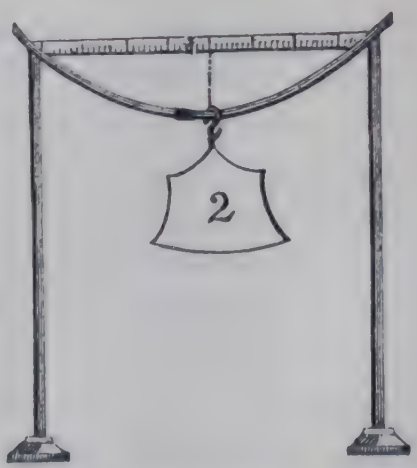

Fig. 37.

Q. 164.—Describe a simple series of experiments to prove that the force by which a liquid floats up a body depends only on the volume of the part of the body immersed and on the density of the liquid.—L.U., 1899.

Q. 165.—"If one end of a skein of silk is placed in a liquid contained in a vessel, and the other hangs over the side, the vessel is found after some time to be empty. How may this have been brought about?"

Q. 166.—In the fig. 13, what are the causes which prevent the jet of water from reaching the level of the water in the vessel?

Q. 167.—"Describe a simple method of determining the exact volume of any body of irregular shape; a stone, for example."

Q. 168.—Explain the action of the common pump with the help of a diagram—L.U., 1901; M.U., 1900; B.U., 1901.

Q. 169.—"Explain the principle of the use of the barometer as an indication of the state of weather."

Q. 170.—Why is it difficult to separate the boards of a bellows after stopping its nozzle and valve-hole?

Q. 171.—State the exceptions to the rule that liquids in communicating vessels reach the same level.

Q. 172.—Mention some of the properties that are peculiar to the liquid state and are not possessed either by solids or gases. In what respect does ice behave like a liquid?—L.U., 1901.

Q. 173.—If two equal pieces of a substance are held suspended by a string so as to be wholly immersed, one in a liquid of sp. gr. .5, and the other in mercury sp. gr. 13·5, which of the strings has a greater tension? And why?

Q. 174.—A cylinder floats vertically in a fluid with 2 feet of its length above the fluid; find the whole length of the cylinder, the specific gravity of the fluid being 13·5 times the cylinder.

UNANSWERED QUESTIONS—*contd.*

Q. 175.—"A piece of cork 3 feet long and 2 feet deep is thrown into water. Find how much of the cork is above the surface, the specific gravity of cork being ·25."

Q. 176.—A solid weighing 50 grains, weighs in water 40 grains, and in another liquid 44 grains. Find out the specific gravity of the liquid.

Q. 177.—Explain why after a man has worked for a considerable time under a diving bell, he finds upon returning to the upper air that he is apparently weak and feeble as everything which he attempts to lift appears to have unusual weight.

Q. 178.—"A piece of wood, specific gravity 0·38, floats in a fluid. Find out the specific gravity of the fluid, if $\frac{1}{4}$ of the wood be above the surface of the fluid."

Q. 179.—A block of stone weighing 156 tons in air weighs 130 tons in water. Find out its cubical contents. [1 c. ft. of water = 62·5 lbs.]

Q. 180.—If a piece of metal weigh in a vacuum 200 grains more than in water and 160 grains more than in spirit, what is the specific gravity of the spirit?

Q. 181.—Explain the statement 'the specific gravity of a body that floats in water is always less than 1.'

Q. 182.—A glass flask provided with a stop-cock is exhausted and the stop-cock closed. Explain what happens if the flask is inverted over water and the stop-cock opened?

Q. 183.—A solid weighing 50 lbs. weighs 35 lbs. in one liquid, and 42 in another; compare the specific gravities of both the liquids.

Q. 184.—A cubic yard of a solid weighs 1,080 lbs. What is its specific gravity? A cubic foot of water weighs 1,000 oz.

Q. 185.—"The bell-jar of an air-pump is 90 c. in. and the barrel 10 c. in. What portion of the air would remain in the receiver after three complete up-down-strokes?"

Q. 186.—A phial partly filled with water has its cork pierced by a tube open at both ends, the lower end being beneath the surface of the water. The air is forced into the phial by means of a condensing pump. State and explain what happens.

Q. 187.—A vessel half filled with water has a cork through which a tube open at both ends passes, the lower end of it dipping under water. Explain what happens, if the vessel is placed under the receiver of an air-pump and the air exhausted.

Q. 188.—A wooden cylinder of uniform density floats in water with its axis vertical and one-third of it above the surface of the water. In another liquid, it floats similarly but with a quarter of the axis above the surface. Find the specific gravity of the liquid.—L.U., 1902.

Q. 189.—Describe the air-pump and explain why it is impossible to produce by it a perfect vacuum. B.U., 1899.

Q. 190.—A common water-pump works well at a place where the height of the mercury barometer is 30 inches, when the distance between the surface of the reservoir and the pump-barrel does not exceed 27 feet. Find what the distance between the surface of the reservoir and the pump-barrel must not exceed, in order that the pump may work well in a place where the height of the mercury barometer is 24 inches.—M.U., 1896.

Q. 191. With what force will a globe filled with hydrogen be pressed up, if the capacity of the globe be 29,800 c. ft. and the weight of the globe be 800 lbs? [*Cf.* Qn. 195.]

Q. 192. Two Magdeburg hemispheres are of such a size that when exhausted they require a weight of 60 lbs. to pull them asunder. Now, if when exhausted they be carried down 33

UNANSWERED QUESTIONS *-contd.*

fathoms in a fresh water lake, what force would it there take to pull them asunder?

Q. 193.—What will be the greatest height of the pump-valve above the surface of the water at which a pump works at a height of 45,000 feet above the sea-level, taking the barometer to be 30 inches at the sea-level?

Q. 194.—Show by a numerical example, other than that in your text-book, how you would find the specific gravity of a solid?—M.U., 1883.

Q. 195.—"Supposing an air-tight bladder containing a cubic foot of air at a depth of about 33 feet in the sea to be brought to the surface, what would it measure then?"

Q. 196.—Find the weight that can be supported by a silk bag filled with hydrogen the capacity of the bag being 3,900 cubic feet and the weight of the bag 40 lbs. (air = $14\frac{1}{2}$ times heavier than hydrogen and 10 cubic feet of air = 1 lb.)

Q. 197.—If a piece of glass float on the mercury within a barometer, will the mercury stand higher or lower in consequence?

Q. 198.—Explain what happens if a syphon tube is filled with mercury and one of the legs placed in a vessel containing water.

Q. 199.—Describe some experiment showing that when a substance is immersed in water, no weight is really lost.—M.U., 1886.

Q. 200.—Our bodies tend to swell if we ascend very great heights. Why is this?

Q. 201.—A wide tube (12 in. long) is corked below and has a narrow tube (6 in. long) open at both ends, passing through its cork. Over this narrow tube a test tube sufficiently wide is inverted. Explain what happens, as you go on filling the wider tube with water.

Q. 202.—What happens, if one of the legs of a syphon which is filled with water be placed in a vessel containing mercury?

Q. 203.—Explain the following statement: "the pressure in a liquid is the same in all directions," and show how this principle has been applied in Brahma's press.—B.U., 1899.

Q. 204.—A load of 100,000 kilograms is to be lifted by a Brahma press. What must be the ratio of the two pistons, if the force applied is 100 kgs. and the arms of the lever are as 1: 10.—B.U., 1899.

Q. 205.—Describe an instrument to ascertain whether two distant points are at the same level, and explain how it is used.—M.U., 1903.

Q. 206.—Explain what is meant by the buoyancy of water, and describe how a vessel can be constructed so as to float in water although made of a substance denser than water.

Q. 207.—Explain the term *comparative* density of a body, and calculate the pressure necessary to force down 20 cubic inches of cork, specific gravity ·25 under an oil, specific gravity ·9, if one cubic foot of water weighs $62\frac{1}{2}$ lbs.

Q. 208. A solid cube of wood, a hollow cube of iron, a solid cube of iron, all of the same size, are placed in water; whereas the first will float, the second may float, and the third will sink. Explain why this is so—M.U., 1902.

Q. 209. A glass tube is bent into a U-shape with arms of unequal length, and water is poured into it until the shorter arm is full. If you now suck at the longer arm, what is the effect (1) if you close the lower end with your finger, (2) if you leave it open? How do you account for the effects?—M.U., 1903.

Q. 210. Draw neat and accurate diagrams of the instruments used in transferring liquids from (1) a lower level to a

UNANSWERED QUESTIONS—*contd.*

higher level, and (2) from a higher level to a lower level, and state the conditions for the working of the latter.

Q. 211.—Describe a simple syphon and explain its action. Why will not a syphon act in a vacuum?—

B.U., 1900; Pun. Ent. 1902; 1904.

Q. 212.—Two masses, one of aluminium and the other of lead, when weighed by a perfectly adjusted balance, balance one another in air, but would no longer do so, if the weighing were made in a vacuum. Explain this, and show which would appear to be heavier in vacuum.—B.U., 1902; L.U., Sept. 1902. [Read the answer to Q. 121.]

Q. 213.—Define 'density.' Calculate the specific gravity of the wood, two ounces of which together with two ounces of iron (sp. gr. 7·8) weigh only one ounce in water.

Q. 214.—What should be the specific gravity of a spherical substance, so that when dropped into a mixture of water and mercury, it remains exactly half immersed in mercury, the other half remaining in water?

Q. 215.—A hollow glass globe and a solid glass globe of the same size are first weighed in the air separately, and then in a vacuum. State, and explain, if either of them loses or gains a greater weight.

Q. 216.—State Pascal's Law regarding pressure in liquids and describe the construction only of the machine in which the law finds an important application.

Q. 217.—Describe a water-level and state how it differs in construction and use from a spirit-level.

Q. 218.—A bladder is first inflated and weighed. Then it is crumpled and reweighed. Would you find any difference? Account for your answer.

Q. 219.—Describe the simple mercurial barometer. State accurately between what points you will measure the height of the column.—M.U., 1898.

Q. 220.—Explain clearly what is understood by saying that the specific gravity of mercury is $13\frac{1}{2}$. A body weighs 88 grains in air; 84 in water; 34 in another liquid. Required the specific gravity of the body and of the liquid.

Q. 221.—Describe experiments to illustrate the buoyancy of water, the varying of the pressure with the depth of the liquid, and the pressure exerted on the mass of a liquid being communicated in all directions.

Q. 222.—Explain with the aid of a diagram the position finally assumed by a glass ball, specific gravity 2·75, when dropped into a vessel containing water and mercury—M.U., 1901.

Q. 223.—How can you test whether a barometer is faulty owing to the presence in it of a quantity of the air?
—M.U., 1901; Pun. Ent., 1901.

Q. 224.—Explain how the common balance helps you in comparing the densities of two given bodies.

Q. 225.—Describe the spouting jar and state what properties of liquids can be illustrated by it.

Q. 226.—Why do not all floating bodies remain immersed to the same extent in the liquid in which they are placed? Calculate the volume of iron which floats with ten cubic inches of it above the surface of mercury; specific gravity of iron 7·8; of mercury 13·5.

Q. 227.—A, B and C are three glass tubes closed at one end and D is another open at both ends. (1) A, which is 32 inches long, is filled with mercury and dipped into a vessel containing water; (2) B, which is 20 inches long, is filled with mercury and dipped into a vessel containing mercury; (3) C, which is 36 inches

UNANSWERED QUESTIONS—*contd.*

long, is filled with water and dipped into a vessel containing water; (4) D, which is filled with mercury, having a false bottom, is dipped into a vessel containing mercury and the false bottom is then removed. Describe in each case the results that follow with reasons, supposing the experiments are made in places near the level of the sea.

Q. 228.—A cube of wood weighing 16 oz. is put into a vessel of water and it is found that when weights amounting to 11 oz. are placed upon it, it floats with its upper surface level with the surface of the water: find the specific gravity of the wood.—M.U., 1889.

Q. 229.—The area of the larger piston of a water press is 25 times the smaller one. Calculate the force with which the larger rises if the smaller is worked by a lever (whose weight arm is to power arm as 5 : 16) with a force of 20 lbs.

Q. 230.—A cylinder, 12 inches in height, floats in water with its upper surface on a level with the surface of water. How will it float in mercury, specific gravity $13\frac{1}{2}$?

Q. 231.—Calculate the total bulk of a substance which floats in a liquid with 50 cubic yards of it above the surface of the liquid—specific gravity of the substance 0·9 and of the liquid 1·025.

Q. 232.—A lead pencil, 6 inches long, floats vertically in water with an inch and a half out of the water. Required the specific gravity of the pencil.

Q. 233.—A thin tin can with a small quantity of water in it was tightly corked while the water inside was boiling, and was then taken away from the flame. The can collapsed a few minutes afterwards. Explain the cause of this.

Q. 234.—Explain why there is a limit to the height to which a liquid can be raised by means of a common pump. What is the limit when the liquid is oil, if the specific gravities of oil and

mercury are 0·8 and 13·6, respectively, and the height of the barometer is 30 inches.

Q. 235.—Show how to determine which of two given fluids is heavier, bulk for bulk, with no other apparatus than a rod weighted at one end and which floats in both.

Q. 236.—Will a solid substance lose more weight by being weighed in hot or in cold water? What must be the temperature of water in which a body loses most weight?

Q. 237.—What depth of water and mercury will exert double the ordinary atmospheric pressure? How would the result be modified if the above were in a place where there is no air?

Q. 238.—One substance is 6 times as heavy as water and another, 4 times as light; find out the volume of the latter that must be attached to 8 cubic feet of the former to make it just float.

Q. 239.—Into a flask weighing 500 grains and containing 1,000 grains of distilled water, when filled to the brim, 270 grains of mercury is poured, the surplus water being allowed to escape. What will be the weight of the flask and contents, the specific gravity of mercury being 13·5?

Q. 240. State how a body denser than water may be made to float on it. What practical application is made of this?

Q. 241. The capacities of the barrel and the receiver of an air-pump are as 1:3. A barometer enclosed in the receiver stands at 28 inches. What will be the height of the barometer after three upward strokes of the piston?

Q. 242.—If a block of metal be weighed by a delicate spring balance in *dry* air, will its weight be the same as when the air is saturated with moisture? Explain fully your answer.—B.U.

Q. 243. If the air is twice as heavy as coal gas and 10 cubic feet of air weigh 1 lb., find what weight can be supported by a

silk bag filled with coal gas whose capacity is 1,885 cubic feet, the weight of the silk bag, etc., being 7½ lbs.

Q. 244.—A cork is floating in water and a glass tumbler is inverted over it and pushed down till it is wholly immersed. In what part of the tumbler will the cork be seen?

Q. 245.—Show experimentally that liquids exert pressure in all directions.—Cal. U., 1902; Pun. Ent., 1903.

Q. 246.—What is meant by the statement that water is a *form* of matter? Explain the principle according to which water is supplied to a town by pipes.—Cal. U., 1903.

Q. 247.—Sketch the leathern collar used in the construction of the water-press, and state (*a*) its position and (*b*) its importance.

Q. 248.—The sp. gr. of an impure piece of gold was found to be 18·5. Supposing it to have been alloyed with silver (sp. gr. 10·5), find the proportion of gold and silver in the piece.—Pun. Ent., 1903.

Q. 249.—A flask holds 27 oz. of water. What weight will it hold of an oil whose specific gravity is ·95? and of mercury, sp. gr. 13·5?—Pun. Ent., 1902.

Q. 250.—"You are given a bladder containing air with its mouth tied. Describe two methods of causing the bladder to become larger without untying its mouth."

Q. 251.—Define or explain the following terms:—force, energy, work. "At the utmost we can get as much work out of a machine as we put into it." Explain the statement with reference to the lever.—Pun. Ent., 1904. [Read the answer to Q. 87.]

Q. 252.—Explain the statement "What is gained in power is lost in time."—Pun. Ent., 1902. [Read the answer to Q. 87.]

Q. 253.—Account for the following:—(1) A body weighs more at the Poles than at the Equator; (2) It is difficult to break a stone; and when broken, the parts do not stick together, even

UNANSWERED QUESTIONS—*contd.*

when brought very close; (3) A bund raised against the overflow of water in a tank is generally broader at the base than at the top.—Up. Com. Exam., 1886.

Q. 254.—Describe three experiments to show that atmospheric air exerts pressure. How would you measure the exact amount of this pressure per square inch at a given locality ?—Pun. Ent. 1901.—[Read the answer to Q. 96.]

Q. 255.—"A test tube full of water is held vertically with its mouth below the surface of some water in a basin, if a hole be made in the closed end of the test tube, what will happen ? Give reasons for your answer."

Q. 256.—"As the day gets hot, the mercury column in a barometer gets shorter, but the mercury column in a thermometer gets longer. Account for this difference."

Q. 257.—Explain, with well chosen illustrations, how you would determine the specific gravity of a liquid with the help of a solid which does not dissolve in water as well as in the given liquid, supposing (1) that the solid sinks in both and (2) that it floats in both.

Q. 258.—Describe a barometer. If the mercury stands at 760 m.m. in a tube 1 c.m. wide, how high will it stand in a tube 2 c.m. wide ?—Pun. Ent., 1900.

Q. 259.—Place a beaker containing water on the pan of a balance and counterpoise it. Take a solid of known volume 5 cubic centimeters and suspend it in the water close by. The pan containing the beaker is depressed. Why ? What weight must be placed in the other pan to restore equilibrium ?

Q. 260.—A body weighing 18 lbs. and sp. gr. 3 is suspended by a string. What will be the pull or tension on the string when the body is suspended in (1) water and (2) a liquid of sp. gr. 2 ?

SECTION III.

ENERGY AND SOUND.

ENERGY.

Q. 261.—What is energy? Give four examples of energy being changed from one form to another.—M.U., 1896.

Ans.—Energy is the power of producing a change in any system of bodies, whereby some resistance is overcome.

(1) When a finger is rubbed against the palm, heat is produced. Here the energy of motion of the finger is converted into the energy of heat.

(2) When a current of electricity is passed through a wire, it becomes red hot. Here electricity is changed into heat and light.

(3) A hammer striking against an anvil, becomes hotter. The energy of motion is changed into the energy of heat.

(4) By rubbing one piece of wood against another, heat is produced, which may be sufficient to set the two pieces on fire.

Q. 262.—State the law that connects the velocity of a moving body with its ability to overcome resistance.—M.U., 1890.

Ans.—The ability of a moving body to overcome resistance is proportional to the square of the velocity of the body.

Q. 263.—In what way does the velocity with which a body strikes the ground depend on (i) its weight; (ii) the height from which it is dropped?—M.U., 1892.

Ans. The weight of a falling body has no effect upon its velocity. All bodies, heavy or light, acquire the same velocity when falling under the influence of gravity. But the height from which it falls has an effect on its velocity—the greater the height from which it falls, the greater is the velocity with which it reaches the earth.

Q. 264.—Define work and explain how it is measured mechanically. What is the relation between work, mass and velocity?—M.U., 1883.

Ans. Work is the result of producing a change in any system of bodies whereby some resistance is overcome through a certain space.

It is measured mechanically by taking into consideration the resistance overcome and the space through which it is overcome. The product is taken to represent the work done. It is measured in the terms of foot-pounds. A foot-pound denotes the amount of work done in raising a weight of 1 lb. through a space of 1 foot and is the unit employed in measuring the work done by anybody.

The work done by a moving body is proportional to the mass of the body.

The work done by a moving body is proportional to the square of its velocity.

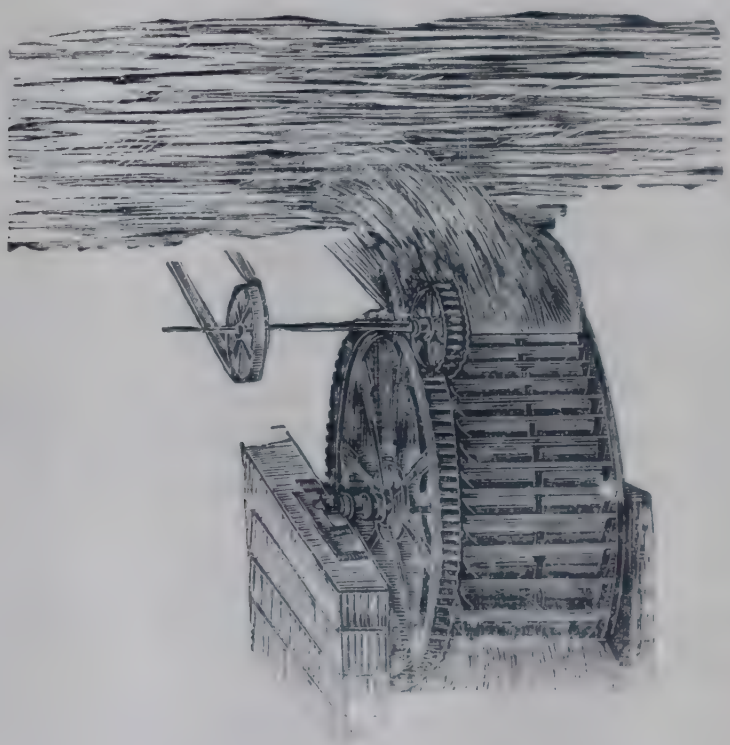

Fig. 38.

Q. 265. – Give four examples to show that inanimate bodies also can do work under some conditions.

Ans. (1) A stone falling from the top of a house can break a pot if one happens to be in its way. (2) A toy train can be made to run by the action of a spring wound up. (3) The blowing wind can make a wind mill work. (4) A running stream, or falling water, can make a water mill work. (Fig. 38.)

Q. 266.—Compare the amounts of energy possessed by two cannon balls, one weighing 10 lbs. and at a height of 10 feet and the other weighing 20 lbs. and at a height of 5 feet, both balls being at rest.—M.U., 1886.

Sol.—The weight of the first ball is 10 lbs.

The height . . . . . 10 ft.

∴ The energy possessed by it=10 × 10=100 ft-pds.

Again, the weight of the second ball 20 lbs.

The height . . . . . 5 ft.

∴ The energy possessed by it=20 × 5=100 ft-pds.

∴ Both the balls possess the same amount of energy.

Q. 267.—Define energy and distinguish between energy in motion and energy in repose. What kind of energy is possessed by a wound-up clock-spring? Give reasons for your answer.—Pun. Ent., 1900.

Ans.—(*Energy*: For definition, *see* answer to Q. 261. *Energy in motion* is otherwise called *Kinetic energy*, and is the energy possessed by moving bodies on account of *their* motion or the motion of their *particles*.

Energy in repose is otherwise called *potential energy*, and is the energy possessed by bodies on account of the peculiar position of these bodies or of their particles.

Examples.—*A stone on the top of a house; water stored up at a height*: these two possess potential energy. Because they are in such a position that gravity is always acting upon them and trying to bring them down.

A wound-up spring; *A bent bow*: these also possess potential energy. Their particles being in a peculiar position, namely, the new position assumed by them on account of being wound up or bent.

A falling stone, a flowing stream, a wound-up spring which is in the act of unwinding itself are all examples of bodies possessing kinetic energy.

Q. 268.—Explain Foot-pound, Power, Horse-power, Conservation of energy, Dissipation of energy and Conversion of energy.

Ans. -The *foot-pound* is the unit employed in measuring the work done by bodies and represents *the work done* in raising a weight of 1 lb. through a space of 1 foot. Thus, we say that the work done by a man is 10 foot-pounds, thereby meaning that he spent ten times the energy required to *raise* 1 lb. through a space of one foot.

The amount of work done by any motor per second is called its *power*. The *Horse-power* is the unit employed in measuring the power of engines and represents a work of 550 foot-pounds per second. An engine of 10 horse-power can perform 550 × 10=5,500 foot-pounds of work in one second, *i.e.*, if it be raising coal from a coal mine, it can raise coal at the rate of 5,500 lbs. to a height of one foot per every second.

Conservation of energy means that energy is uncreatable and indestructible. One form of energy may be changed to another form, but can never be destroyed. 'The energy in the universe is a constant amount.' A good example of conservation of energy is in connection with the electric spark. To get a spark from the electric machine, it has to be turned. Here the muscular energy is transformed into the energy of electrical separation, which is again transformed into the energy of heat and light of the spark produced.

Dissipation of energy.—In its transformations, a portion of the energy will be distributed among the surrounding things, so that it is not possible to say exactly what form it assumed. The energy thus lost is said to be dissipated.

Conversion of energy. -Sometimes one form of energy disappears as such, but re-appears in another form. This is known as the transformation of energy, *e.g.*, when a hammer falls on the anvil, the energy of the falling hammer disappears as such when arrested by the anvil, but is transformed into the energy of sound produced, and heat developed in the anvil.

Q. 269. How may the energy of the wind be stored up so as to do work during a calm, and how may the amount of this stored energy be measured?—M.U., 1904.

Ans.—The wind may be made to work a wind-mill. This wind-mill may be made to work a water-pump or force-pump and thus draw or force water up to a height. The water stored up in that way possesses energy. The energy of wind may now be said to be stored up in the form of energy possessed by the water at a height.

The water at the height may be made to run down in calm weather and work a water-mill.

The amount of energy stored up is measured by the work it will do when allowed to fall again, or it is measured by the quantity of water raised (estimated in pounds), and the height through which it has been raised (estimated in feet).

Q. 270.—A bullet is directly fired into a number of planks placed one behind the other and after passing through one plank comes to rest. Another similar bullet is now fired at the planks and comes to rest after passing through three planks. Compare the velocities with which these two bullets were moving.—M.U., 1896.

Sol.—The work done by a moving body is proportional to the square of the velocity.

∴ the velocity of a moving body is proportional to the square root of the work done.

Now the first bullet passed through 1 plank, and the second, through 3 planks.

∴ the second did three times the work done by the first.

∴ the velocity of the second is $\sqrt{3}$ times the velocity of the first.

Q. 271.—State and explain the laws of energy.

(i) The amount of energy possessed by a moving body is proportional to the mass of the body, *e.g.*, a body weighing 8 lbs. and moving at a rate of 10 miles per hour has greater energy than a body of 6 lbs. moving at the same rate.

(ii) The energy possessed by a moving body is proportional to the square of its velocity, *e.g.*, a body moving at the rate of 80 feet per second possesses four times the energy possessed (and, hence, can do four times the work done) by a body of the same weight moving at the rate of 40 feet per second. A bullet shot with a certain velocity pierces through 4 planks of wood; a similar bullet when shot with thrice the velocity pierces through $(3)^2 \times 4 = 36$ planks.

Q. 272.—A pointed knife dropped from a height of 2 feet pierces 16 leaves of a book: dropped from another height it pierces 144 leaves. What was the second height from which it was dropped? Compare the velocities with which the knife met the book in the two cases.—M.U., 1882.

The work done in the first case is piercing through 16 leaves.

And in the second case, piercing through 144 leaves.

∴ The work done in the second case is nine times the work done in the first case.

∴ *Height in the second case.*—The work done by a falling body is proportional to the height from which it falls. Hence the height in the second case is nine times the first, *i.e.*, $9 \times 2 = 18$ ft.

Velocity in the second case.—The velocity of a moving body is proportional to the square root of the work done. Hence the velocity in the second case is $\sqrt{9}$, *i.e.*, three times the first.

Q. 273.—"Work, force and energy are not one and the same." Explain this.

Ans.—FORCE IS DIFFERENT FROM WORK.—A simple illustration will make the difference between 'force' and 'work' clear. Suppose we go on *dragging* a weight of 50 lbs. through a space of 100 yds. To drag this weight of 50 lbs. you require some force, without applying which it cannot be dragged at all. This necessary force will all along be the same—it will never increase or decrease *so long as the weight to be dragged is 50 lbs.* But the amount of work done differs—it is greater if the weight is drawn through a greater distance, and less if drawn through a less distance. *The work done by a body, therefore, depends upon* (i) *the magnitude of the force and* (ii) *the space through which the force acts.* In learning that force is different from work you should bear in mind that 'there is no work done by the force acting, unless there be actual motion' of the force through a certain distance in the direction of the force.

FORCE IS ALSO DIFFERENT FROM ENERGY.—Energy is not the same as force; it is the power of making a force act through a certain distance. Take an example: *A* drags a weight of 50 lbs. through 100 yards, while *B* drags it through 50 yards. Both of these apply the same force, but the energy spent by the former is greater than the energy spent by the latter.

Q. 274. Give examples of actual and of stored energy and explain how each is measured. One kind of gun-powder gives a bullet 50 per cent. more velocity than another kind. If a bullet shot with the first kind pierces 4 inches of a plank, how far would a similar bullet shot with the second kind pierce the same plank?—M.U., 1893.

Ans.—(1) A wound-up spring when unwinding itself, (2) water falling from a height, (3) blowing wind, (4) a bullet discharged from a gun are examples of bodies possessing actual energy.

(1) Spring wound up, (2) water at a height, (3) a bow bent, (4) a stone on the top of a house are examples of bodies possessing stored up energy.

Stored up energy is measured by the work which the body possessing it can do, if allowed. Hence it is the product of resistance (weight) and the space through which the resistance acts.

Actual energy is measured by the work done. In doing this, velocity of the body also is taken into account. $E=\frac{1}{2}MV^2$.

Sol.—The work done by a body is proportional to the square of the velocity.

In the given case the velocity of the second bullet is $1\frac{1}{2}$ times the first.

$\therefore$ the work done by the second bullet is $(1\frac{1}{2})^2=\frac{9}{4}$ the first.

The work in the first case is piercing through 4 inches.

$\therefore$ in the second case $\frac{9}{4}\times 4=9$ inches.

Q. 275.—Calculate the horse-power of the engine which could raise 1,500 cubic feet of water per hour from a depth of 300 yds. [1 c. ft. of water weighs $62\frac{1}{2}$ lbs.]

Sol.—1.500 c. ft. of water weighs $1.500\times\frac{125}{2}$ lbs.

Depth=900 ft.

$\therefore$ in 60 minutes the work done $=\frac{900\times 1,500\times 125}{2}$ ft. pds.

$\therefore$ 1 do. do. $\frac{900\times 1.500\times 125}{2\times 60}$ ft. pds.

But 33,000 ft. pds. per minute=1 H.P.

$\therefore \frac{900\times 1.500\times 125}{2\times 60}$ . . . . . $=\frac{900\times 1,500\times 125}{2\times 60\times 33,000}$

$=42{\cdot}6$ H.P.—*Ans.*

Q. 276. A blacksmith can make a piece of iron red hot by hammering it. How do you account for the heat thus produced?
—M.U., 1888.

Ans.—Each time the hammer strikes the iron, the motion of the hammer is stopped. It is converted into the motion of the particles of iron. This molecular motion gives rise to heat. Kinetic energy of the falling hammer is changed into the heat energy of the iron.

Q. 277.—A stone weighing 3 lbs. rises 16 ft. when projected upwards with a velocity of 32 ft. per second. How high does it rise when projected with twice the velocity? What amount of energy does it contain?

Sol.—The velocity in the second case is twice the velocity in the first and hence the work done will be (2^2) times. In the first case the work done is rising 16 ft.

$\therefore$ in the second case it rises . . . $4 \times 16 = 64$ ft.

The energy possessed $= 64 \times 3 = 192$ ft. pds.

Q. 278.—If a balloon weighing altogether half a ton, rise one mile in the air, what is the mechanical measure of the work done? (*a*) Show that gravity is the source of the energy that does this work.—M.U., 1881.

Sol.—The weight of the balloon $= \frac{1}{2} \times 20 \times 4 \times 28 = 1.120$ lbs.

The height risen through $= 1 \times 1.760 \times 3 = 5.280$ ft.

$\therefore$ the work done $= 1.120 \times 5.280 = 5.913.600$ ft. pds.—*Ans*

(*a*) The air exerts upward pressure. As a result of this, the balloon rises in the air. If the gravity did not act upon the air, the pressure of the air due to its weight would not exist; the lower layers react against the downward pressure of the upper layers, and in doing so press upwards, and give rise to buoyancy. A thing lighter than an equal volume of the air is forced upwards, and hence it rises. Hence, the source of energy is gravity.

Q. 279.—A substance weighing 5 lbs. and moving with a velocity of 20 ft. per second does 30 units of work. How much work will another substance weighing 30 lbs. and moving with a velocity of 15 ft. per second do?

Sol. 5 lbs. moving at 20 ft. per second does 30 units of work

$\therefore$ 1 lb. do. do. do. $\frac{30}{5} = 6$ do.

[because the work done by a moving body is proportional to the mass; and the mass now is one-fifth].

$\therefore$ 1 lb. moving at 1 ft. per second does $6 \times \frac{1}{20} \times \frac{1}{20} = \frac{6}{400}$ units of work

[because the work done is proportional to the square of the velocity; in this case the velocity is one-twentieth of the above.]

$\therefore$ 30 lbs. moving at 1 ft. per second does $\frac{6}{400} \times 30$ units of work.

$\therefore$ 30 lbs. do. at 15 ft. per second does $\frac{6}{400} \times 30 \times 15 \times 15 = 101{\cdot}25$ ft. pds.

SOUND.

Q. 280.—Give three experimental proofs that a sounding body is in a state of rapid vibration. Heat is said to be a rapid vibration of the particles of a body. If this is so, why can we not hear heat?—M.U., 1894.

Ans.—1. If a number of pith balls are so suspended as to touch the sides of a vessel, all these pith balls will be seen to rise and fall when the vessel is made to emit a sound, thus showing that the vessel is in a state of vibration.

2. If a person touches the strings of a fiddle or of a harp when it is played upon, the music will cease to be heard and the vibratory motion of the strings will be felt. If, instead of touching the strings, he places on them a pencil lightly held between his fingers, the pencil will be seen to rise and fall.

3. If a small and light mirror be attached to one of the prongs of a tuning fork and light be reflected from the mirror, a spot of the reflected light will be seen somewhere on the opposite wall. So long as the tuning fork does not emit a sound, this spot of light remains stationary. If, however, the fork is made to emit a sound, the spot of light on the wall will be seen to move forwards and backwards very quickly, although the vibrating motion of the tuning fork may not be visible.

We do not hear heat, though heat is due to the vibratory motion of the particles of a body, because (1) these vibrations are too quick to affect the ear and (2) these vibrations do not set up aerial waves, which alone can affect the ear.

Q. 281.—How could it be shown that sound cannot be propagated in a place where there is no air?

Ans.—This fact may be verified by the apparatus illustrated here. It consists of a glass globe provided with a stopcock and has a bell attached to it inside as represented in fig. 39. The bell may be made to produce sound by a simple shaking of the globe, and this sound is distinctly heard when the interior of the globe communicates with the outside. Now exhaust the air inside the globe and turn the stopcock. If the globe is taken up and given a shake, the sound produced will not be heard as loud as before, but will be extremely feeble. If the air in the globe be completely exhausted, the sound of the bell would not be heard at all.

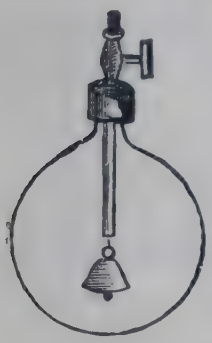

Fig. 39.

Q. 282.—How does sound move? Show how you could calculate the distance of a flash of lightning by noting the interval of time between the flash and the thunder. M.U., 1888.

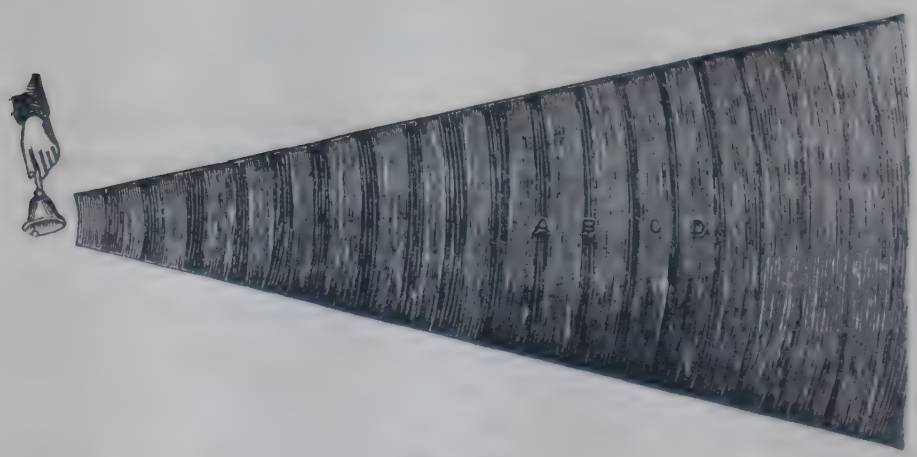

Fig. 40.

Ans. Sounds are generally propagated by means of waves set up in the air by the vibratory motion of the sounding bodies. These waves are caused in the air by the vibrations of the sounding body. Vibration is the moving of a body forwards and backwards. When the body moves forwards it pushes the air next to it and, so, it is compressed, and when it moves backwards there is a rarefaction of the air on the same side. Thus the air next to a sounding body is alternately compressed and rarefied, and these compressions and rarefactions are passed on quickly as they are produced

These compressions and rarefactions make up the aerial waves mentioned above. These waves entering the ear of a man act on his tympanum and make him hear a sound (fig. 40).

Sound travels in air at the rate of 1,100 feet per second. Light travels with enormous velocity. So, the lightning is seen almost immediately after it is produced. Hence, by multiplying the number of seconds that elapse by 1,100 we can know the distance of the flash in feet.

Q. 283.—A dozen similar glass balls are laid in a smooth horizontal groove, each ball just touching the next; if two of the balls be taken and rolled smartly against one end of the row, state briefly what will happen and what this illustrates.—M.U., 1890.

Ans.—The two at the other end will fly off. The balls in the middle do not move *visibly*. This shows that motion may be transmitted through matter and illustrates how sound is propagated through the air without the air itself going all the way to the hearer.

Q. 284.—How has the velocity of sound in open air been determined?—L.U., 1902.

Ans.—Two hills near Amsterdam were chosen as stations, the distance between the two being 11 miles. At each of the stations there were observers. At one of the stations a gun was fired and the observer at the other station noted down first the exact time when he saw the flash of the gun and then the time when he heard the report. The interval in time between the flash and the sound was the time taken by the sound to go over the space of 11 miles. (The flash was seen almost at the time when it was produced, for light travels at the rate of 186,000 miles per second and so, the distance of 11 miles would be passed over by the light in no time.) Calculating from this, the velocity of sound in air was found to be 1,093 feet per second at 0° C. This velocity, however, increases, as the temperature rises—*at the rate of 2 feet for every degree.*

Q. 285.—How would you prove by experiment that sound takes time to travel?—M.U., 1891. How could you estimate the *speed of sound* by means of echoes?—M.U. 1891; 1896; 1901.

Ans.—(1) The axe of a person felling a tree at a distance will be seen to fall on the tree first while the sound produced will be heard later on. (2) Similarly, when a washerman strikes clothes against a rock, the act will be seen first and the sound heard afterwards. (3) When a gun is fired at a

distance, the flash and the smoke issuing out of the muzzle will be seen first and the sound heard after a time.

Note the distance of the reflecting body from the hearer. Note the time that elapsed between the original sound and the echo. This is the time which sound took to pass from the hearer to the obstacle and back from the obstacle to the man, *i.e.*, twice the distance from the hearer to the obstacle. Divide *this* distance by the number of seconds that elapsed between the sound and its echo; and that is the speed of sound in the air.

Q. 286.—A musical box having been set in motion is placed under the receiver of an air-pump. Describe and account for the effects produced by exhausting the air.—M.U., 1889.

Ans.—As the air is exhausted, the sound becomes feebler and feebler, because the loudness of a sound depends upon the density of the air *at the place where the sound is produced.* By the time the receiver is fully exhausted the sound will cease to be heard, although the musical box may be seen to be working. The reason is that sound cannot be propagated in a place where there is no material medium.

Q. 287.—What is the rate per second at which sound passes (i) through air, (ii) through water, (iii) through wood or iron, (iv) through a vacuum?—M.U., 1881. Arrange the following in the order of the speed of sound in them, beginning with that in which the speed is highest: air, water, wood.—

M.U., 1896.

Ans.—The rate of sound per second in air ... 1,100

" " water ... 4,700

" " wood ... 11,000

" " iron ... 16,500

Sound does not pass through a vacuum.

The order required—wood, water, air.

Q. 288.—(*a*) How do you account for the fact that no sound is heard when a bell is rung in a vacuum? (*b*) When a great explosion takes place on the shore of a lake a man in a boat far out on the lake hears two reports. Explain this.—M.U., 1886.

Ans.—(*a*) Sound requires material medium for propagation. It is propagated by means of waves set up in the air. There is no air in the place and, hence, no waves are set up by the sounding body, although the bell may be struck there.

(*b*) The sound produced is propagated through the water as well as through the air. The rate at which it is propagated through water is greater. Hence the report first heard is due to sound propagated through water, and the subsequent one is due to the sound through the air. [*Cf.* Q. 301].

Q. 289.—A loud peal of thunder makes the doors and windows of houses to rattle. Explain the reason.—M.U., 1882.

Ans.—The waves set up in the air by thunder are so powerful that they pass onwards and make the doors shake. Sound is a form of energy. The wave motion in the air caused by the noise of thunder possesses enough energy to make the windows and doors rattle.

Q. 290.—Give examples of vibrating bodies producing (i) a musical sound, (ii) a noise, (iii) no sound. Account for the difference in the effects produced.—M.U., 1895.

(i) The note produced by the string of a fiddle when the bow is drawn across it.

(ii) The report of a gun.

(iii) Musical box in a vacuum : A heated body.

Reasons.—

(i) The vibrations are produced at regular intervals and, hence, the note is pleasant to hear.

(ii) In this case a violent and sudden push is given to the air. The sensation is not continuous and, hence, it is merely a noise.

(iii) Though the box may be seen to be working, the vibratory motion is not propagated, for there is no material medium to propagate it. Hence, the body is vibrating, but no sound is produced.

A heated body does not produce sound. The particles vibrate, but those vibrations do not set up waves in air and, hence, no sound is produced.

Q. 291.—How could you prove that sound obeys the laws of reflection ?

Ans.—Place a watch in front of a concave mirror, as shown in fig. 41, a little beyond the focus towards the mirror. On applying the ear at E, the ticks of the watch will be distinctly heard. This is because the sound waves striking the mirror, (1) undergo reflection from the mirror, and (2) meet at E in accordance with the laws of reflection.

Q. 292.—A soldier firing at a target sees the bullet hit the target in two seconds after he fires and he *hears* the bullet hit the target in three seconds after he sees it do so. How far is the target from him and what is the average velocity of the bullet in miles per hour?—M.U., 1894.

Sol.—The space between the soldier and the target is passed over by sound in three seconds.

In 1 second sound passes over 1,100 ft.

∴ 3 „ „ „ 3,300 ft.

∴ The target is 3,300 ft. from the soldier.—**Ans.**

In 2 seconds the bullet passes over 3,300 ft.

∴ 1 „ „ „ 1,650 ft.

∴ 1 hour „ $\frac{1,650}{1,760 \times 3} \times 60 \times 60 = 1,125$ miles per hour.

Fig. 41.

Q. 293.—What is the cause of an echo? A man shouts in front of a high rock and hears his own shout repeated five seconds afterwards; how far away is the rock? Explain the steps of your calculation.—M.U., 1883; 1893.

Ans.—When there is an obstacle through which sound cannot pass, it will be reflected. In some cases the reflected sound is *completely and distinctly* heard; this is an *echo*. An echo will be produced, when the distance between the sounding body and the obstacle is sufficiently great—so great that the original sound and the reflected sound do not interfere. If the distance between the sounding body and the obstacle be not sufficiently great, then the reflected sound interferes with the original sound.

Sol.—In five seconds the sound passes over $5 \times 1,100 = 5,500$ ft.

∴ 5,500 ft. is the distance between the man and the obstacle + the distance between the obstacle and the man; because in echo, the sound passes from the man to the obstacle and from the obstacle back to the man.

∴ 5,500 ft. is twice the distance between the man and the obstacle.

∴ The distance between the man and the obstacle is $= \frac{5,500}{2} = 2,750$ ft.

Q. 294. How was it proved that sound obeys the laws of refraction?

Ans. A lens of glass was constructed "by cutting equal segments out of a large collodion balloon and fastening them on the two sides of a sheet-iron ring a foot in diameter, so as to form a double convex lens about 4 inches thick in the centre (fig. 42). This was filled with carbonic acid gas—a gas denser than the air—and a watch was placed in the direction of the axis: the point was then sought on the other side of the lens at which the sound was most distinctly heard. It was found that when the ear was removed from the axis, the sound was scarcely perceptible, but that at a certain point B on the axial line it was very distinctly heard. Consequently the sound waves in passing from the lens had emerged towards the axis, their direction had been changed; in other words they had been refracted."

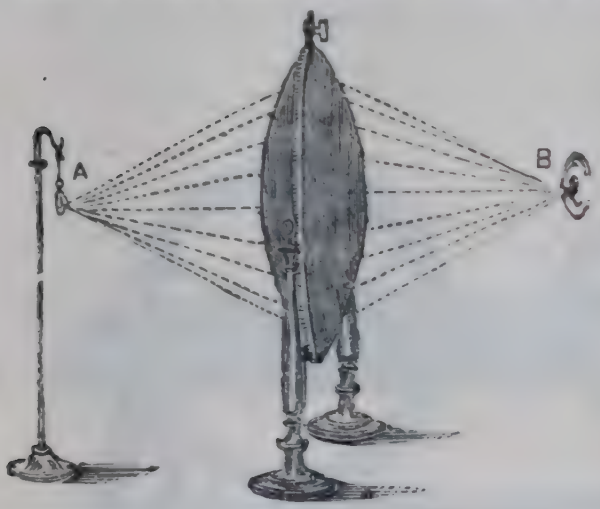

Fig. 42.

Q. 295.—Standing between two cliffs a person fires a gun and hears the echoes due to the cliffs simultaneously after four seconds. Calculate how far the cliffs are apart from each other, giving reasons for the steps you take.

Ans.—Suppose *A* and *B* are the two cliffs and *C* the person.

To pass from *C* to *B* and back from *B* to *C* the sound takes four seconds.

To go from *C* to *B* it takes two seconds; but sound travels at the rate of 1,100 ft. per second. Hence in two seconds it passes over 2,200 ft.

∴ the distance between *C* and *B* is 2,200 ft.

∴ For the same reasons the distance between *C* and *A* is also 2,200 ft.

∴ the distance between *A* and *B* is $= 2,200 + 2,200 =$ **4,400 ft.**

Q. 296.—What is meant by the pitch of a musical note? Is a loud note the same as a high note? Give reasons for your answer.—M.U., 1884; 1893.

Ans.—'Pitch' denotes the acuteness or graveness of a musical note and depends upon the number of vibrations per second of the sounding body.

No. Loud note is not the same as a high note. Loud note depends upon the intensity of sound and is the opposite of a feeble note. High note depends upon the number of vibrations per second and is the opposite of a low note.

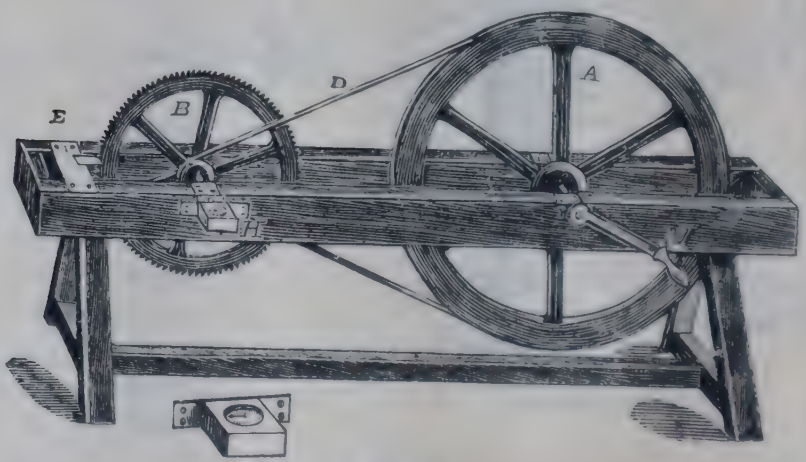

Fig. 43.

Q. 297.—Explain fully a method of ascertaining the pitch of musical note.—M.U., 1881; 1885.

Ans.—The question means '*how would you find out the number of vibrations* made by a sounding body in a given time?' This can be done in more ways than one. One of them is by means of 'Savart's Toothed Wheel.'

Its various parts. (1) A toothed wheel with a known number of teeth mounted on an axis (B. fig 43). (2) A small wheel on the same axis, called the multiplying wheel. (3) A big wheel (A) which is connected with the multiplying wheel by a strap (D) and which can be turned by means of a handle (M). (4) A piece of card-board (E) fixed in such a way that it may be struck by the teeth of the toothed wheel when revolving. (5) An indicator (H) by the side of the toothed wheel and connected with its axis to indicate the number of revolutions of the wheel. All these various parts are mounted on a frame.

Its action.—Turn the large wheel by means of the handle. The multiplying wheel also revolves and makes the toothed wheel revolve. The toothed wheel, in its revolution, strikes the card. First, each tick may be separately heard, but as the velocity of the wheel increases a continuous note will be heard, the pitch of which will rise higher and higher as the velocity with which the wheel revolves is increased. Go on turning the wheel more or less rapidly, until you get a note of the same pitch as the one to be examined. When you have got such a note, continue the rotation at the same speed for sometime, say a minute. The indicator tells you the number of revolutions made by the toothed wheel during this minute. Multiplying the number of revolutions by the number of the teeth of the wheel, you get the total number of ticks during the minute, and by dividing the number by 60 you can have the number of vibrations per second.

[*Another way of determining the pitch of a sound*:—Procure a tuning fork (A) which is known to give out a certain number of vibrations per second, say 500. Attach a light pencil to one of its prongs and another to the body (B) the pitch of which is to be determined. Allow both of these pencils to lightly touch a paper rolled round a cylinder rotating on its axis (O) in the fixed nut (D) by means of the handle (E). (Fig. 44). Make both the tuning fork and the other body emit notes and then begin to turn the handle. Both the body and the tuning fork will vibrate and make the pencils attached to them trace wave-like lines on the paper. Then unroll the paper and spread it, which then presents the appearance represented in F. Count the waves produced by both. Suppose the tuning fork (A) traced 100 curves and the body (B) 150. We know that the tuning fork traces 100 curves in 1/5th of a second. Since in 1 5th of a second the body vibrates 150 times, its pitch is 750 per second.]

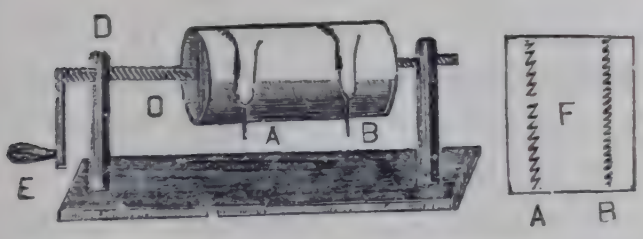

Fig. 44.

Q. 298.—What is meant by the intensity of sound? State the conditions that affect it.

Ans. The intensity of a sound is the force with which the sound is heard. The following are the *causes* which influence the intensity of sound:—

(i) *The distance of the sounding body from the hearer.*—The intensity of the sound produced will be greater when the sounding body is nearer. The farther the body, the feebler the sound.

(ii) *The density of the air where the sound is produced.* If the air where the sound is produced is less dense, the sound is more feebly heard than when the air is denser. The sound of the alarm under the receiver of an air-pump becomes feebler and feebler, as the exhaustion proceeds.

(iii) *Currents of wind.*—The intensity of sound changes with the direction of the currents of wind. Sound is heard more feebly when the currents of wind are away from the hearer than when the currents of wind are towards him.

(iv) *The presence of strengthening apparatus.*—Sound will be intensified, if the sounding body is placed over or near an apparatus which strengthens the sound. The sound produced by a string, however tightly stretched, will not be audible; but, when it is mounted over a sounding box, it will be heard. So also a tuning fork may not be audible when struck, but the sound will be intensified, when the fork is mounted ove a sounding box.

Q. 299.—State the conditions which affect the pitch of a note, and explain why a fiddler constantly moves his fingers along the strings of the instrument, and why the strings of the instrument are not all of the same thickness.

Ans.—(i) *The length of the sounding body*: Other things being equal, the longer a body is, the smaller the number of vibrations given out by the body per second, and hence the lower the pitch of the note produced. This is the reason why in instrumental music the players constantly move their fingers up and down the strings of fiddles, harps, etc. By moving their fingers up and down and pressing over the necessary parts, they can shorten or lengthen *the vibrating portion* of the string and thus obtain notes of different pitch.

(ii) *The thickness of a sounding body*:—Other things being equal, the number of vibrations produced by a sounding body is inversely proportional to its diameter, *i.e.*, the thicker the body is, the less the number of vibrations produced by it per second, and so the deeper the sound. This is the reason why the strings of a fiddle or of a harp are not all of the same thickness. The thicker ones produce deeper notes, and the thinner ones, higher notes.

Q. 300.— A bullet is fired from a rifle with a velocity of 1,760 feet per second and is heard to strike a target in $3\frac{1}{4}$ seconds afterwards; required the distance of the target from the marksman.

Sol.—Suppose the distance to be 1 ft.

∴ To go over this distance, the bullet takes $\frac{1}{1,760}$ sec. and the sound produced returns in $\frac{1}{1,100}$ sec.

∴ If $\left(\frac{1}{1,760} + \frac{1}{1,100}\right)$ sec. be the time that elapses between the firing of the gun and the hearing of the report, then the distance is one ft.

Hence if $3\frac{1}{4}$ secs. be the time, the distance is $\frac{1,760 \times 1,100}{2,860} \times \frac{13}{4} =$ 2,200 ft. **Ans.**

Q. 301.—When an explosion takes place on the shore of a lake a man in a boat far out in the lake hears two reports. Calculate how far the man is from the shore when the interval between the reports happens to be $6\frac{1}{2}$ secs. [Read the answer to Q. 288.]

Sol.—Suppose the distance to be 1 ft. Then, one sound will be heard through the air in $\frac{1}{1,100}$ sec. and another sound will be heard through the water in $\frac{1}{4,700}$ sec., for the velocity of sound in water is 4,700 ft. per second.

The interval is $\frac{1}{1,100} - \frac{1}{4,700} = \frac{47-11}{51,700} = \frac{36}{51,700}$.

If $\frac{36}{51,700}$ sec. be the interval, the distance is 1 ft.

∴ If $6\frac{1}{2}$ secs. „ „ „ $\frac{51,700}{36} \times \frac{13}{2}$ ft.

∴ The distance of the man is $\frac{51,700 \times 13}{36 \times 2 \times 3 \times 1,760} = 1$ m. $6\frac{1}{2}$ ft. nearly.

UNANSWERED QUESTIONS.

Q. 302.—Why ought the water at the bottom of a waterfall to be warmer than at the top?—L.U., 1899.

Q. 303.—A bullet is fired directly into a number of planks placed one behind the other and after passing through one plank comes to rest. Another similar bullet is now fired at the planks and comes to rest after

UNANSWERED QUESTIONS—*contd.*

passing through three planks. Compare the velocities with which these two bullets were moving.

Q. 304.—Distinguish between force and energy, and define kinetic and potential energy.—B.U., 1899.

Q. 305.—Two exactly similar cannon balls are fired directly at a piece of armour plate and pierce it to a depth of 6 and 9 inches respectively. Compare the velocities of the two cannon balls.—M.U., 1902.

Q. 306.—A man whose weight is 160 pounds and whose eyes are 5 ft. 6 in. from the ground, wishes to jump sufficiently high to see over a wall 7 ft. high. How much work must he perform in order to accomplish this? Explain how it is that the energy he expends in doing this must have come from the sun.—L.U., 1900 Jan.

Q. 307.—"A pointed knife, dropped from a certain height, pierces through 20 leaves of a book; dropped from another height, it pierces 40 leaves. Compare the velocities with which the knife met the book in the two cases?"

Q. 308.—Trace the transformations of energy that take place in a railway engine when at work.—L.U., 1900 June.

Q. 309.—"A man weighing 140 lbs. has a load of 100 lbs. on his back and carries it up a ladder to a height of 50 feet. How many foot-pounds of work does he do altogether? What part of this work is done usefully?"

Q. 310.—How does the amount of energy possessed by a moving body vary with the velocity of the body, and how can the law be verified?

Q. 311.—"Energy only changes forms, and never absolutely disappears." Explain this with the help of two suitable examples.

Q. 312.—"A cannon ball discharged with the velocity of 1,000 ft. per second will pierce through six planks of oak: through how many similar planks will a similar ball pierce when discharged with a velocity of 2,500 ft. per second?"

Q. 313.—What must be the horse-power of an engine in order to raise 14 tons of coal per hour from a pit 80 fathoms deep?

Q. 314.—"A winding engine is observed to raise a tub of coal weighing 4 cwt. in 4 minutes from a pit 60 fathoms deep; required the horse-power of the engine.

Q. 315.—A body shot up with a velocity of 64 ft. per second rises to a height of 104 ft.; to what height will the same body rise if shot up

UNANSWERED QUESTIONS—*contd.*

with a velocity of 192 feet per second and how much energy does it contain when starting?

Q. 316.—A shot travelling at a certain rate can bury itself 10 ft. in sand; how far could a shot travelling with double that speed bury itself?

Q. 317.—Describe the apparatus mentioned in the primer by means of which we can find the number of times a sounding body is vibrating per second; and explain its use.—M.U., 1881. [Read the answer to Q. 297.]

Q. 318. Standing between two cliffs, I give a shout and hear two echoes; how can I calculate how far the cliffs are apart?—M.U., 1883.

Q. 319.—Distinguish between the loudness and the pitch of a musical note.

Q. 320.—Distinguish between the two kinds of energy, and state the exact relation between the amounts of work done by a moving body with different velocities.

Q. 321.—A gun was fired at A; an echo of it due to the obstacle B was heard by a person standing midway between A and B twenty seconds after he heard the gun. Calculate the distance between A and B.

Q. 322.—A toothed wheel which has 45 teeth is made to revolve at the rate of 1.000 revolutions per minute. What is the pitch of the note produced when a card is held against it as it revolves?—M.U., 1897.

Q. 323.—How can it be proved that sound obey the laws of reflection? State the laws.

Q. 324.—What is the physical difference between a noise and a musical note, and between a high note and a loud note?

Q. 325. How, by means of a revolving toothed wheel, could you produce all the sounds mentioned in Q. 322?—M.U., 1898.

Q. 326.—Give reasons for the following:—(1) The report of a pistol on the top of a mountain is not louder than the sound of a common cracker. (2) The voice of a person speaking in a large hall seems to be intensified, but confused.

Q. 327. Show by a diagram how the direction of sound may be changed, and give two examples.—M.U., 1900.

Q. 328.—"If a man can work at the rate of 210.000 foot-pounds an hour, how long would it take him to raise a weight of 10 tons through 150 ft. supposing him to be provided with a suitable machine?"

Q. 329.—"A person fires a gun and listens for the echo from a rock 11 miles distant. When will he hear the echo?

UNANSWERED QUESTIONS—*contd.*

Q. 330.—A traveller finds himself between two nearly parallel and precipitous mountain ranges which are about 2.200 ft. apart, while the road through the valley runs about 550 ft. from one of the sides. On firing his gun he hears three distinct echoes, the second hearing considerably fainter than the first, while the third is almost as loud as the second. Explain this, and calculate the time lapsed between the hearing of each echo and the firing of the gun."

Q. 331.—When a gun is fired a loud sound is heard. (1) What is the cause of the sound? (2) At what distance is the gun if the sound is heard 4 seconds after the flash is seen?—M.U., 1903.

Q. 332.—Describe how sound is transmitted from the source to the ear and mention any observation by which your description is supported.—M.U., 1901.

Q. 333.—How is it to be explained that a sound is propagated by air with an average velocity of 1.100 ft. per second, while the greatest velocity with which air moves during the most violent hurricane is only 80 ft. per second?

Q. 334.—At one end of a very long tube a pistol is fired. Explain how it happens that an observer at the other end of the tube hears the report twice.

Q. 335. Explain (i) why, when a tuning fork is struck and the stem pressed against the table, it sounds much louder than when in hand only; (ii) why the sound in the former case continues not near so long as in the latter.

Q. 336. A man weighing 160 lbs. does altogether 7.200 units of work in carrying a bag of rice up a stair 24 feet high. What is the weight of the bag?

Q. 337.—A cannon ball weighing 300 lbs. and shot with a velocity of 400 ft. per second pierces through 1.200 planks of wood; through how many similar planks will another ball weighing 400 lbs. and shot with a velocity of 300 ft. per second pierce?

Q. 338.—Why is the ticking of a watch indistinctly heard, if placed on a cushion?

Q. 339. Compare the energy of a body weighing 4 lbs. and moving with a velocity of 5 ft per second with that of another weighing 5 lbs. and moving with a velocity of 4 ft. per second.

UNANSWERED QUESTIONS—*contd.*

Q. 340.—Is the disturbance produced in the surrounding air by a sounding body the same as that caused in a pool by a stone thrown into the water? State the points of resemblance and the points of difference.

Q. 341.—Give the laws of reflection of sound. Explain the production of echoes. If the reflecting surface is within the minimum distance an echo cannot be clearly heard; Why is that? What is that distance?—B.U.

Q. 342. Distinguish between sound and noise. Define 'pitch' and 'intensity' of sound. Explain why a sound is better heard when travelling with the wind than when travelling against it.—B.U., 1901.

Q. 343.—In what way does a deep low note differ from a shrill high note? On what physical elements does the loudness and pitch of a note respectively depend? Punj. Ent., 1903.

Q. 344.—How may the distance of a lightning flash be approximately calculated?—Punj. Ent,, 1903.

Q. 345.—How would you proceed to determine the vibration frequency of a given note? L.U., 1902 September; Punj. Ent., 1904. [Ref. to Q. 297.]

Q. 346.—Describe an experiment to show that a string when giving a musical sound is vibrating regularly.—Pun. Ent., 1902.

Q. 347.—Explain the term 'Conversion of Energy' with reference to a well-chosen example. A cannon ball discharged with the velocity of 1,000 ft. per second will pierce through six planks of oak; through how many similar planks will a similar ball pierce when discharged with a velocity of 4,500 ft. per second?

Q. 348.—How are echoes produced? How could an echo be made use of to determine the velocity of sound in air?—Lon. Mat, 1902, June. [Ref. to Q. 285.]

Q. 349.—A flash of lightning is seen and nine seconds after the noise of thunder is heard. Calculate the distance of the cloud from the observer.—Pun. Ent., 1900.

Q. 350.—"Apply the laws of energy to find out the velocity with which a stone weighing one pound should be projected upwards so as to rise two feet high."

Q. 351.—"Standing at some distance from a quarry, I hear two sounds at an interval of ten seconds in consequence of a blow the workman has given to the rock. Find the distance, supposing the earth to transmit sound ten times as fast as air."

SECTION IV.

HEAT.

Q. 352.—Give some of the reasons which lead us to believe that heat is not matter but a form of energy.—M.U., 1893.

Ans.—(1) Take an iron ball and weigh it carefully in a balance. Take it out, make it red hot, and weigh it again. The weight will exactly be the same as before and there will be *no gain* of weight whatever. If heat were matter, then there would have been an increase in weight; but there is no such increase in weight. Heat, therefore, is not matter, but is a form of energy. (2) If we rub one of our fingers against the palm of the other hand we feel it hot after a time. Why? Because the energy of motion of the finger is transformed into the energy of heat. When a smith strikes on an anvil with a hammer, the anvil after a time grows hot. Why? Each time the hammer is stopped by the anvil, its energy of motion is converted into heat-energy. Heat, therefore, is a form of energy and not matter, because (i) it does not possess weight, (ii) it may be produced from other forms of energy, and (iii) it can be converted into other forms of energy. In a steam engine heat is transformed into motion of the train, or of some other thing.

Q. 353.—Compare and contrast the energy of sound with the energy of heat.

Ans.—

Resemblance.	Difference.
1. Both are forms of energy. 2. Neither is matter. 3. Both are due to the vibratory motion in bodies. 4. Both are reflected on meeting an obstacle.	1. Sound affects the ear and heat affects the touch. 2. Sound requires a material medium for propagation. 3. Heat does not require any such medium for propagation. 4. The velocity of heat is very much greater than that of sound.

Q. 354.—What is meant by 'source of heat'? State and explain the different sources of heat.

Ans.—The '*source of heat*' means the way in which heat is produced.

All the sources of heat may be divided into two: Physical and Chemical.

Where heat produced is the result of some change *in the state* of a body, the source is physical, *e.g.*, heat produced by friction, by electricity, by change of state—in all these cases the source is physical.

Where heat is the result of some change *in the composition of a body*, the source is chemical, *e.g.*, heat produced when firewood burns or when water is poured on quicklime.

Q. 355.—State and explain the different effects which heat may bring about in bodies.

Ans.—In some cases bodies are entirely changed giving rise to new things. Such changes are called chemical changes. Therefore, sometimes heat produces chemical changes in bodies, *e.g.*, (i) when paper is burnt, (ii) when wood is burnt, and (iii) when chalk is burnt, entirely new things are produced.

In some cases, heat changes only the state of a body. Such chang are called physical changes. Therefore heat produces also physical changes, *e.g.*, when an iron bar is heated, it becomes bigger in size. Here heat expands iron, *i.e.*, makes iron larger in volume. The physical effects are:—(1) Heat expands bodies, *i.e.*, makes them increase in volume; (2) Heat raises the temperature of bodies, *i.e.*, makes bodies hotter and hotter; (3) Heat changes the state of the body, *i.e.*, heat changes a solid into liquid, and a liquid, into gas.

Q. 356.—How would you show in a simple manner the expansion by heat of a solid, a liquid and a gas?—M.U., 1881.

Ans. -1. Take an iron bar (AB fig. 45) which is fixed at one end B and

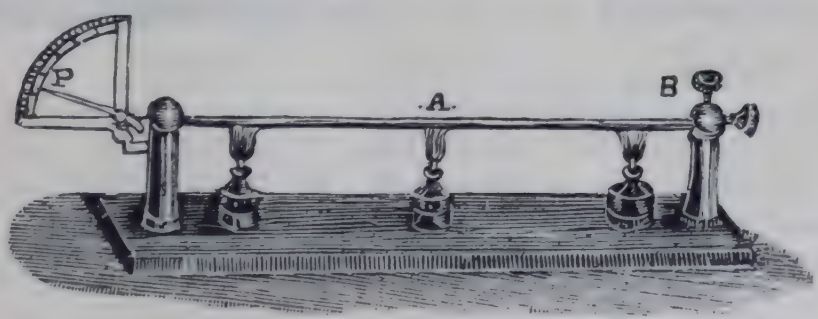

Fig. 45.

free to move at the other end as shown in fig. 45. Let the free end press against a lever P which moves along the scale. Now heat the iron bar as

shown in the fig. The pointer will shortly be seen to move. The pointer moves on account of its being pushed by the bar in expanding.

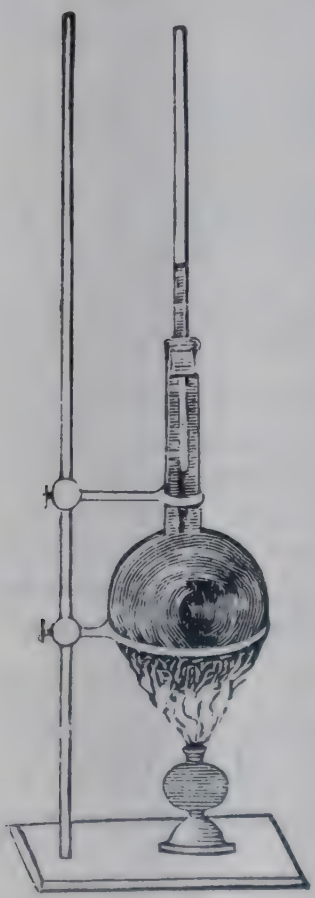

Fig. 46.

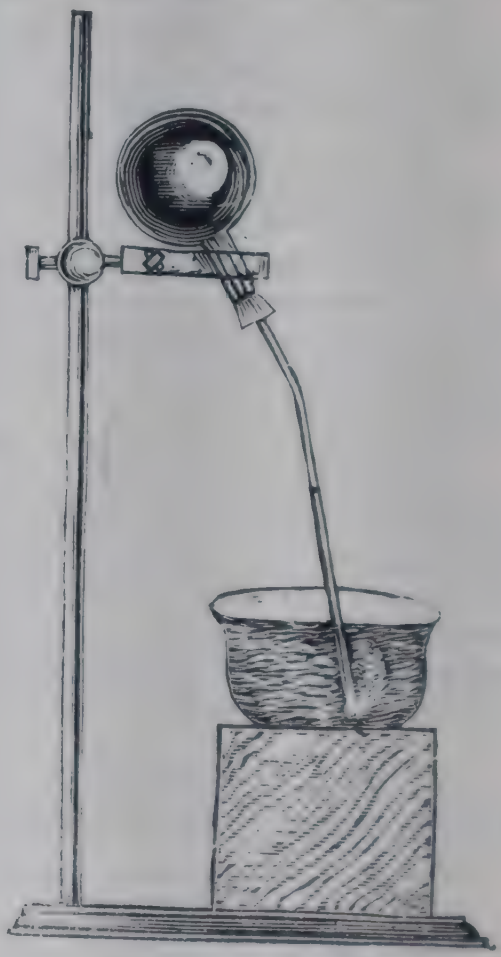

Fig. 47.

(2) Take a flask and fill it with water. Colour the water, so that it may be seen in the flask. Cork the flask. Through the cork pass a glass tube open at both ends as shown in fig. 46. Heat the flask and shortly afterwards the liquid will be seen to rise in the tube: because the heat applied to the flask has made the water inside become larger in volume and occupy some space. **Hence it rises in the tube.**

(3) Take a flask and fit it with a cork. Let a tube open at both ends pass through the cork. Place the flask in the position shown in fig. 47. Let the outer end of the tube dip under a coloured liquid.

Now heat the flask gently. Bubbles will be observed to escape through the liquid. This is on account of the expansion which the air in the

flask has undergone when heated. Having no place for it in the flask, it goes out in bubbles.

Q. 357.—"Bodies expand when heated and contract when cooled. Is this consistent with the fact that in the rainy season doors and windows fit more tight than in summer."

Ans.—Yes; it is. The reason why windows and doors fit more tight in the rainy season is that they become larger on account of the moisture which those bodies absorb. In summer that moisture is driven out as vapour and so these bodies come back to their usual size.

Q. 358.—'Liquids expand when heated'; but when a flask containing water is heated, the water shrinks a little in the flask. Account for this and state what happens if heated further.

Ans.—When heat is applied to the flask, the substance of the flask first expands. As the flask thereby becomes bigger, the liquid inside will appear to shrink. If the heat be continued, the liquid also will be heated, and as the rate of expansion of a liquid is greater than the rate of expansion of a solid, the liquid will expand more when heated further and rise in the flask.

Q. 359.—In fig. 47 what happens when the source of heat is removed? How would you find out the amount of air that has gone out at the end of the experiment?

Ans.—Immediately after the source of heat is removed a bubble or two of the air may still escape; for the air remains in the expanded state and fills the flask. But as it cools down the air in the flask contracts. Thus a vacant place is produced and the outside air tries to rush in. But there is water in its way and so it presses over the water. The water rushes into the flask to take the place of the air that has gone out. By measuring the water that gets into the flask we can determine the quantity of the air that has gone out.

Q. 360.—A piece of silver sinks in molten silver while a piece of cast iron floats over molten cast iron. Account for these facts and state the use of cast iron in arts on account of the property illustrated by the fact mentioned.

Ans.—Heat expands bodies. Therefore as silver is heated it goes on expanding. Molten silver is, therefore, lighter than solid silver, bulk for bulk. Hence solid silver sinks in liquid silver.

To the rule that 'application of heat expands bodies and removal of heat makes them contract' there are some exceptions. Cast iron is one of them. When cast iron melts it contracts instead of expanding; and when molten cast iron cools and becomes solid, it expands instead of contracting. Molten cast iron is, therefore, heavier bulk for bulk than solid cast iron. **Hence solid cast iron floats on liquid cast iron.**

As molten cast iron expands when solidifying, it is used for casting purposes. Cast iron is largely used in arts for pillars, etc. When molten cast iron is poured into a mould, it expands in becoming solid and enters into the nooks and corners of the mould. It, therefore, assumes the form of the mould accurately.

Q. 361.—Why is water a partial exception to the rule that 'heat expands bodies.'

Ans.—Water above 4° C. when heated expands and when cooled contracts, *e.g.*, water at 30° C. when heated expands and when cooled contracts. But when water below 4°C. is heated it contracts and when cooled expands; for example, water at 3° C. when heated contracts and when cooled expands. As water behaves contrary to the general rule, only when below 4° C. and in accordance with the general rule when it is above 4°C., it is said to be a partial exception to the rule that 'heat expands bodies.'

Q. 362.—Explain how water, being a partial exception to the general rule that heat expands bodies, is of great importance in nature.

Ans.—When bodies of water are exposed to severe cold they become frozen. As water below 4° C. behaves contrary to the general rule, the interior remains liquid at 4° C. and the surface only becomes ice. Thus the animal life in the body of the water is preserved. If it were not for this, the whole water would be frozen, resulting in the destruction of the animal life. Suppose, for example, a lake has water at 20° C. As winter approaches the upper layers fall in temperature and contract. Becoming heavier they go down and the lower layers go up. The upper layers again fall in temperature and they go down. This goes on till the whole of the lake reaches 4° C. Now when the upper layers fall down in temperature further, they expand instead of contracting. Becoming lighter they remain at the top. They fall from 3° C. to 2° C. and at last become converted into ice, but all the while remain at the top, and the water in the interior remains liquid at 4° C.

Q. 363.—Explain why water at 4° C. weighs more than the same volume of water at any other temperature.

Ans.—If water at 4° C. be heated, it expands. So, it becomes lighter bulk for bulk. If water at 4° C. be cooled, then also it expands because, when below 4° C. water is an exception to the general rule. So, now also it becomes lighter bulk for bulk. Hence water at 4° C. has greater weight than an equal volume of water at any other temperature.

Q. 364.—Explain what is understood by saying that the maximum density of water is at 4° C.

Ans.—This means that water has greater quantity of matter when at 4° C. than an equal volume of it at any other temperature; for example, 1 c. ft. of water at 4° C. weighs more than 1 c. ft. of water at any other temperature.

Q. 365.—Explain what is meant by the 'temperature of a body' and state how it is measured.

Ans.—(1) 'Temperature' denotes the state of a body with regard to the heat that can be felt in it, and is the condition of heat which determines its flow from one body to another. When two bodies are brought into contact, heat passes from the body of higher temperature to that of the lower one. The temperature of a body is measured by the instrument 'Thermometer,' and the words used in expressing it are 'degrees.' We say that the temperature of a body is forty degrees or fifty degrees as the case may be.

Q. 366.—'In most cases the heat applied to a body raises its temperature; in some cases it does not.' Give examples to illustrate these facts and say what becomes of the heat when it does not go to raise the temperature of the body.

Ans.—'To raise the temperature of a body' means 'to make the body hotter than before.' Water and other things when heated become hotter. But when ice, which is about to melt, is heated it becomes water as cold as the melting ice. In such cases where the heat applied does not go to raise the temperature of the body, it is spent in changing the state of the body from solid to liquid, or liquid to gas.

Q. 367.—Give some practical applications of the fact that solids expand when heated.

Ans.—(1) A little space is left between the ends of the rails in making up a railway line. The object of this is to allow for the expansion of the rails. (2) When iron beams and girders are used in the construction of a building, an open space is left in the wall at the end of each beam to allow the beam to expand freely when necessary, without pushing the wall.

Q. 368.—(1) What is a thermometer used for? (2) What are the properties of bodies upon which the action of a common thermometer depends?—M.U., 1899.

Fig. 48.

Fig. 49.

Ans. – (1) The thermometer is the instrument used to measure the temperature of a body.

(2) The action of a common thermometer depends upon the following properties of bodies: – (i) Heat expands bodies, and liquids expand more than solids for the same rise in temperature. (ii) When bodies are brought into contact, heat flows from bodies of higher temperature to bodies of lower temperature, till the bodies assume the same temperature.

Q. 369.—What are thermometers? Classify them with reference to the highest temperatures that can be measured by them.

Ans.— Thermometers are instruments by means of which the temperature of bodies can be measured.

(1) Alcohol thermometers are used to measure very low temperatures, and are so called, because the liquid used in them is alcohol.

(2) Mercurial thermometers are used to measure ordinary temperatures, including the temperature of boiling water; they are so called because the liquid used in them is mercury.

(3) Pyrometers are instruments used to measure temperatures so high that mercurial thermometers cannot be used to measure them.

Q. 370.—Explain how a mercurial thermometer is made and state how many kinds of mercurial thermometers there are. Account for their names.

Ans.—To make a mercurial thermometer take a glass tube with a bulb at one end, a funnel at the other end, and a uniform narrow passage throughout. Pour mercury into the funnel (fig. 48). Heat the bulb. The air inside expands and escapes in the form of bubbles through the mercury in the funnel. On allowing the tube to cool, the air inside contracts and a part of the mercury in the funnel gets into the tube. By heating and cooling the bulb alternately fill the whole of the bulb and a part of the tube with mercury. Now heat the bulb till the mercury inside boils. The vapour of mercury drives out the air, and there remains only mercury and its vapour inside. Then remove the funnel and close the open end by melting. So far, in the construction of a mercurial thermometer, the *filling* is over. Then it is to be marked with degrees. The number of degrees depends upon the kind of thermometer to be made.

There are three well known kinds of mercurial thermometers—(1) Reaumur's thermometers: they are called after Reaumur who designed the scale; (2) Fahrenheit's thermometers are called after Fahrenheit who designed that scale; (3) Centigrade thermometers are so called because there are 100 degrees on them (fig. 49). The person who designed this scale was Celsius.

Q. 371.—State the points of difference and of resemblance in the three recognized thermometers.

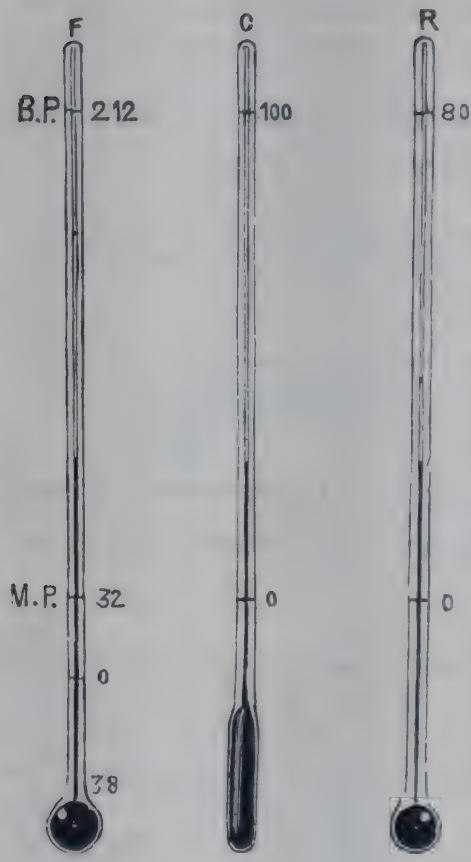

Fig. 50.

Ans.—After filling the bulb and closing the open end the fixed points are marked. The Freezing Point and the Boiling Point are known as the fixed points. The fixed points are, therefore, common to all the three thermometers. (Fig. 50.)

The space between the fixed points is divided into a different number of divisions in the three. The fixed points are numbered differently in the three. The countries wherein they are used are different. These points of difference are shown in the following table :—

Name of the thermometer.	A Country where it is used.	How the Freezing Point is denoted.	How the Boiling Point is denoted.	Number of Divisions between the Freezing Point and the Boiling Point.
(1) Centigrade.	France ...	0	100	100
(2) Fahrenheit.	England ...	32	212	180
(3) Reaumur ...	Russia ...	0	80	80

Q. 372.—What are the Fixed Points? Why have they been so called? How are they marked on a thermometer?

Ans.— The Fixed Points denote two important temperatures. One of them, the Freezing Point, denotes the temperature at which water begins

to become ice; it is also known as the Melting Point, because ice must reach that temperature before beginning to become water. The other point is known as the Boiling Point and denotes the temperature of water when boiling at the sea-level. These two are called *fixed points*, because they denote always constant temperatures, and because in the construction of recognised thermometers they are marked first.

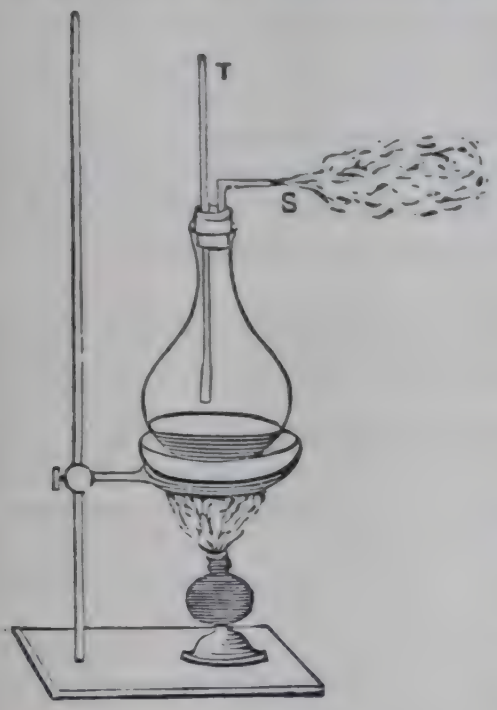

Fig. 51.

To mark the Freezing Point the instrument is plunged into melting ice. The mercury inside contracts and the place where it stands is marked. This is known as the Freezing or Melting Point. To mark the Boiling Point, the instrument is plunged into the steam coming out from water boiling at the sea-level (Fig. 51). The mercury inside expands and rises to a certain height. The place where it stands is marked. This is known as the Boiling Point.

Q. 373.—What is meant by 'melting ice'? On a Fahrenheit thermometer where does the mercury stand when the instrument is plunged into melting ice. What is the zero point according to this thermometer? Why has that temperature been called zero?

Ans. 'Melting ice' means ice which is about to melt, *i.e.*, such ice that will begin to melt and become water when heat is applied.

When plunged into 'melting' ice the mercurial column in a Fahrenheit thermometer contracts and stands at 32. The zero point according to this thermometer is the temperature of a mixture of equal weights of sal-ammoniac and snow. This temperature was called zero because this was "the lowest then known and was wrongly thought to represent absolute cold."

Q. 374.—What are Pyrometers? Explain their construction and use.

Ans.—Mercury being a liquid becomes converted into vapour at a high temperature. Mercurial thermometers cannot, therefore, be used to measure very high temperatures. Pyrometers are used to measure higher temperatures than what the mercurial thermometers can measure. In these instruments the chief part is a metallic rod and it is arranged somewhat in the way shown in fig. 45. The expansion of the bar for a certain range of temperature is first determined. Suppose that the bar expands and makes the pointer move over two divisions when exposed to the temperature of boiling water. Then, in a case where the heat is so intense as to cause the bar to expand and make the pointer move over 12 divisions, that heat must be taken to be six times as intense as that of boiling water, *i.e.*, to be 600 °C.

Q. 375.—What are Alcohol thermometers? What is their use?

Ans.—Mercury becomes frozen at low temperatures. A mercurial thermometer cannot be used to measure very low temperatures. To measure temperatures too low to be measured by mercurial thermometers, alcohol thermometers are used. These thermometers have in them alcohol instead of mercury, as alcohol is a liquid which does not freeze even at low temperatures.

Q. 376.—Why is it necessary to consult the barometer in marking the Boiling Point of a thermometer?

Ans.—The Boiling Point is marked by plunging the instrument into the steam of boiling water. A liquid can boil even at a lower temperature if the pressure of the atmosphere above be reduced. In order that the boiling points marked on different thermometers may denote the same temperature, it is necessary that they should be marked when water boils under a certain pressure. The pressure chosen is the pressure at the sea-level, or where the barometer stands at 29·9 inches. Hence, the barometer is to be consulted to mark the Boiling Point of a thermometer.

Q. 377.—Why is mercury the liquid selected for filling a thermometer?

Ans.—(1) Being a liquid it expands moderately.

(2) Its rate of expansion between 0° C., 100° C., is uniform.

(3) It is converted into vapour at a high temperature.

(4) It takes up heat very quickly.

(5) It does not stick to glass, and therefore moves freely in the tube.

(6) Its brightness enables us to observe the movement of the liquid in the tube clearly.

Q. 378.—What happens if the bore of a thermometer be not uniform?

Ans.—The temperature of a body is measured by inserting the thermometer into the body and noting the expansion caused in the mercurial column in the tube of the thermometer. If the tube be not uniform, the expansion caused cannot be rightly measured. Therefore the temperature of the body cannot be correctly ascertained, if the tube be not uniform.

Q. 379.—What are the different parts of a thermometer? How are marks made upon a thermometer?

Ans.—(i) A bulb filled with mercury and (ii) a graduated stem attached to the bulb containing a narrow and uniform passage partly filled with mercury. To make marks on a thermometer they make use of an acid called Hydrofluoric acid. This acid eats into glass but not into wax. The instrument is, therefore, coated with melted wax and parts of the wax are removed, wherever required. It is then put into the solution of Hydrofluoric acid which acts upon the glass and not upon the wax. Marks are thus made upon a thermometer.

Q. 380.—Arrange the following substances in order of their expansibility by heat :—Oxygen, glass, mercury, air, water, steel, alcohol and lead. Give reasons for your arrangement.—M.U., 1894.

Ans.—The following is the order, commencing with those that expand most :—

Oxygen, air.
Alcohol, water, mercury.
Glass, steel and lead.

Reasons for the arrangement: (i) Of all substances gases expand most and solids expand least.

(ii) Of the liquids those that have a higher Boiling Point expand at a lower rate than those that have a lower Boiling Point.

Q. 381.—What is the meaning of 'minus' when used in connection with the reading of a thermometer? What is the temperature of a substance according to a Reaumur thermometer when a centigrade thermometer reads—10° C.?

Ans.—The word 'minus' when used in connection with a thermometer means *below zero degree.* '—10°C' is read *minus ten degrees centigrade* and means ten degrees below 0.

Sol.—The reading is 10 degrees below 0° C.

In C. the zero is the Freezing Point.

But 100 divisions on C = 80° on R.

$\therefore$ 10 „ „ $= \frac{80}{100} \times 10 = 8$ on R.

$\therefore$ In R. the reading is 8 divisions below 0,

Hence the reading according to R = —8° R.

Q. 382.—A measure of water in a vessel A is 10° C. A measure of water in a vessel B is 41° F. Which of these is of a higher temperature?

(*N.B.*—In answering questions of this kind both temperatures are to be brought to the same scale, and then compared. In (1) both are brought to the Centigrade Scale: In (2) both to the Fahrenheit Scale.)

Ans.—(1) The Freezing Point in Fahrenheit is 32.

$\therefore$ the mercury stands 9 divisions above the Freezing Point.

But 180 divisions on F = 100 on C.

$\therefore$ 9 „ = 5 on C.

$\therefore$ the temperature of the water in B is five divisions above the Freezing Point.

The Freezing Point in C. being marked 0, the temperature of water in B is 5° C.

But the water in A is 10° C.

$\therefore$ A contains the hotter water.

(2) 100 divisions on C = 180 on F.

$\therefore$ 10 divisions on C = 18 on F.

$\therefore$ the water in A is 18 divisions above the Freezing Point according to the Fahrenheit thermometer. But the Freezing Point in the Fahrenheit thermometer is marked 32.

∴ the temperature of A according to F. is 32+18=50° F. But B is only 41° F.

∴ A contains the hotter water.

Q. 383.—Which of the following is the heavier of the two?

(1) A measure of water at 10° C. or
a measure of water at 41° F.

(2) A measure of water at 2° C. or
a measure of water at 37° F,

Ans.—(1) 41° F=5° C. as shown in Qn. 382.

Above 4° C. water follows the general rule of expansion of bodies by heat and expands as the temperature rises. So 1 measure of water at 10° C. is lighter than 1 measure of water at 5° C., *i.e.*, at 41° F.

(2) 37° F.=5 divisions above the Freezing Point, for the Freezing Point is marked 32 in the Fahrenheit thermometer.

But 180 divisions on F. = 100 divisions C.

∴ 5 „ „ $= \frac{100}{180} \times 5 = 2\frac{7}{9}$° C.

∴ according to C. $2\frac{7}{9}$ divisions above the Freezing Point. But the Freezing Point in C. is marked 0.

Therefore the temperature of water at 37° F. is $2\frac{7}{9}$° C.

Water below 4° C. behaves contrary to the general rule. So, water at $2\frac{7}{9}$° C. is denser than at 2° C. Therefore a measure of water at 2° C. is lighter than a measure of water at $2\frac{7}{9}$° C. or 37° F.

Q. 384.—The temperature of a mixture of ice and salt is 0° F. What is its temperature according to C. and R.?

The Zero degree in F. is 32 divisions below the Freezing Point.

∴ The mercury in F. stands 32 divisions below F. P.

In C. and R. also the mercury stands below the Freezing Point.

180° in F. = 100 in C. and 80 in R.

∴ 32 „ $= \frac{5}{9} \times 32$ in C.; and $\frac{4}{9} \times 32$ in R.

But the Freezing Points in C. and R. are marked 0.

∴ the mercury in C. stands $17\frac{7}{9}$ divisions below 0, and $14\frac{2}{9}$ divisions below 0 in R.

∴ the reading is—$17\frac{7}{9}$° C.; and—$14\frac{2}{9}$° R.

[There are equations expressing the relations between the readings of the various thermometers. Equations I and II express the relations between F. and the other two thermometers. The sums given must first be worked out in the method suggested above. Then they may be verified by the equations.

I. $C=\frac{5}{9}\times(F-32)$. II. $R=\frac{4}{9}\times(F-32)$.

Let us verify the results in Question 384.

$\therefore 0^\circ F=\frac{5}{9}\times(0-32)=-17\frac{7}{9}^\circ C.$

$\therefore 0^\circ F=\frac{4}{9}\times(0-32)=-14\frac{2}{9}^\circ R.$]

Q. 385.—The temperature of a body is 40° R. What is its temperature according to F. and C. thermometers ?

Sol.—In R. the mercury stands 40 divisions above the Freezing Point.

In F. and C. also it stands above the Freezing Point.

But 80 divisions in R=180 in F. and 100 in C.

$\therefore$ 40 „ = 90 in F. and 50 in C.

But the Freezing Point in Fahrenheit is 32.

$\therefore$ The reading according to F. is $90+32=122^\circ$ F.

The Freezing Point in Centigrade is 0.

$\therefore$ The reading according to C. is 50° C.

[Equations III and IV express the relation between R. and other thermometers.

III. $F=\frac{9}{4}R+32$. IV. $C=\frac{5}{4}R$.

$\therefore$ In the above sum R=40

$\therefore F=\frac{9}{4}\times 40+32=122^\circ$ F.

$\therefore C=\frac{5}{4}\times 40=50^\circ$ C.]

Q. 386.—The temperature of a liquid is -40° C. What is the temperature of it according to R. and F. ?

Sol.—The mercury in the centigrade thermometer stands 40 divisions below Zero 0. *i.e.*, below the Freezing Point.

In F. and R. also the mercury stands below the Freezing Point

But 100 divisions on C. are=180 on F. and 80 on R.

$\therefore$ 40 „ „ $=\frac{9\times 40}{5}$ on F. and $\frac{80\times 40}{100}$ on R.

∴ In F. the mercury stands 72 divisions below the Freezing Point. But F. P. is marked 32.

∴ The reading is 32 − 72 = −40° F.; and in R. the reading is 32° R.

[Equations V and VI connect C. with F. and R.—

V. $F=\frac{9}{5}C+32$. VI. $R=\frac{4}{5}C$.

Let us verify the answers in Question 386.

∴ $F=\frac{9}{5}\times-40+32=-72+32$, or −40° F.

∴ $R=\frac{4}{5}\times-40=-32$° R.]

Q. 387.—Does the meaning of the word 'thermometer' correctly express what the instrument actually does?

Ans.—No. 'Thermometer' means 'heat measurer'; but what a thermometer measures is not the heat in a body, but its temperature.

Q. 388.—Explain clearly what is meant by specific heat and latent heat, and describe any simple experiment to illustrate each. A bottle, *A*, contains a certain weight of water, and another, *B*, the same weight of mercury. I place both at the same temperature, 100° C. in a room at 25° C. Will *A* or *B* get cooled first? Explain clearly why?—M.U., 1887.

Ans.—*The Specific heat* of a body is the number of Thermal Units required to raise one pound of the body through one degree centigrade.

Latent heat is the quantity of heat required to convert a solid into liquid or a liquid into vapour without raising its temperature.

Example to illustrate specific heat.—If 1 lb. of water at 100° C. is mixed with 1 lb. of water at 0° C. the resulting temperature will be 50° C.; but if 1 lb. of mercury at 100° C. is mixed with 1 lb. of water as 0° C., the resulting temperature will be only about 3° C., showing that the specific heat of mercury is very low.

Example for latent heat.—After water reaches its boiling point, it absorbs a quantity of heat and becomes converted into steam at the same temperature.

B becomes cooled first. The specific heat of water is about 30 times greater than mercury. Hence by the time the water falls by 1° C., the mercury will fall by 30° C., because it is only then that the amount of heat given out by both will be the same.

Q. 389.—How would you prove that different substances have different specific heats?—M.U., 1891.

Ans.—Take 10 lbs. of water in a vessel. Heat it over a spirit lamp for some time and note the rise in the temperature of the water. Suppose the water rises through $X°$ C. Next take 10 lbs. of mercury in a vessel and heat it over the *same* spirit lamp, for the *same* length of time. The mercury will be found to rise thirty X degrees.

Another proof for the same fact:—Take a lb. of mercury at 100° C.: mix it with a pound of water at 0° C. The resulting temperature will be less than 3° C.; but if 1 lb. of iron at 100° C. be mixed with 1 lb. of water at 0° C., the resulting temperature will be above 9° C.

Q. 390.—Explain the difference between quantity of heat and temperature.

Ans.—The quantity of heat in a body denotes the amount of heat in it and depends upon (i) the mass of the body, (ii) its temperature, and (iii) the specific heat of the body; it is measured in the terms of 'Thermal Units.' The temperature of a body depends entirely upon the intensity of the heat in the body and is measured in the terms of 'degrees.'

Q. 391.—Define specific heat and explain how it is determined by the method of mixtures.—B.U., 1901.

Ans.—The specific heat of a body is the number representing the ratio between the heat required to raise 1 lb. of that substance through one degree and the heat-quantity required to raise 1 lb. of water through 1° C.

In *the method of mixtures.*—the substance whose specific heat is to be determined is weighed; suppose it weighs 4 lbs.

It is then raised to a certain temperature; suppose to 80° C.

The substance is then immersed in water, whose weight and temperature are known; suppose it is immersed in 6 lbs. of water at 15° C.

After the temperature has become uniform, the final temperature is observed; suppose it is 20° C. (This means that the substance fell from 80° C. to 20° C. and water rose from 15° C. to 20° C.; so that the heat given out by 4 lbs. of the substance in falling through (80 − 20) = 60° raised the temperature of 6 lbs. of water through (20 − 15), *i.e.*, 5 degrees.)

∴ 4 lbs. of the substance contains in 60 degrees 6×5 or 30 T. U.

The specific heat of the substance $= \frac{30}{4 \times 60} = \frac{1}{8}$ *Ans.*

Q. 392.—Explain: Degree, Unit of heat, Liquefaction, Vaporization.

Ans.—*Degree* is the word used in expressing the temperature of a body, and denotes the space between any two consecutive lines on the stem of a thermometer.

Unit of heat is the quantity of heat required to raise 1 lb. of water through 1° C. and is the standard for measuring the quantity of heat. It is otherwise known as 'Heat-Unit' or 'Thermal Unit.'

Liquefaction is the process whereby a solid or a gas is converted into liquid. The process of changing a solid into liquid is called 'melting' and that of changing a vapour into liquid is called 'condensing.'

'*Vapoziation*' is the process of converting a solid or liquid into the gaseous form.

Q. 393.—Will the resulting temperature of water be the same in the following two cases? (*a*) 1 lb. of mercury at 100° C. is poured into 1 lb. of *water* at the freezing temperature. (*b*) 1 lb. of mercury at the freezing temperature of water is poured into 1 lb. of water at the boiling point. If not, explain clearly, why not?—M.U., 1882.

Ans.—No. (*b*) Will be at a much higher temperature than (*a*).

Reason.—Owing to the low specific heat of mercury (·03) 1 lb. of mercury at 100° possesses 3 Units of heat which is distributed over the mixture in (*a*). In the second case, owing to the high specific heat of water 1 lb. of water at 100° C. has 100 Units of heat which is distributed over the similar mixture in (*b*). Hence (*a*) will be at $2\frac{97}{103}$° C. and (*b*) at $97\frac{9}{103}$° C.

Q. 394.—Compare the quantity of heat required to raise 12 lbs. of water from 35° C. to 75° C. with the heat given out when 15 lbs. of water at 68° C. are cooled down to 38° C.

Sol.—When 1 lb. of water is raised through 1° C=1 T. U. is required.

When 12 lbs. of water are raised through (75—35) or 40° C. $12 \times 40 = 480$ T. U. are required.

Again, 1 lb. of water falling through 1° C. gives out 1 T. U.

∴ 15 lbs. of water falling through (68—38) or 30° C. gives out 30×15 or 450 T.U.

The heat in the first case is to the heat in the second case as 480 : 450, *i.e.*, 16 : 15.

Q. 395.—Calculate the result in the following cases: (1) 4 lbs. of boiling water are poured upon 3 lbs. of ice at 0° C. (2) 2 lbs. of boiling water are mixed with 12 lbs. of mercury at 35° C. [Sp. Ht. of mercury ·03].

Sol.—(1) 4 lbs. of boiling water contain $4 \times 100 = 400$ T. U.

Of these $3 \times 79 = 237$ T. U. are spent in changing 3 lbs. of ice at 0° C. into water at 0° C.

∴ We have $(4+3)=7$ lbs. of water containing $400 - 237 = 163$ T. U.

∴ the temperature is $\frac{163}{7} = 23°$ C.

∴ The result is 7 lbs. of water at 23° C. nearly.

(2) 2 lbs. of boiling water contain $2 \times 100 = 200$ T. U.

12 lbs. of mercury at 35° C. ,, $12 \times 35 \times \frac{3}{100} = 12\frac{3}{5}$ T. U.

Now, the question may be put thus: To what temperature will a mixture of 2 lbs. of water and 12 lbs. of mercury at 0° be raised by applying to it $(200 + 12\frac{3}{5}$ T. U.)

To raise 2 lbs. of water through to 1° C we require 2 T. U: and to raise 12 lbs. of mercury through 1° C. ,, $= 12 \times \frac{3}{100} = \frac{9}{25}$ T. U.

∴ To raise a mixture of 2 lbs. of water and 12 lbs. of mercury through one degree we require $\left(2 + \frac{9}{25}\right.$ T. U.

Now, $2\frac{9}{25}$ T. U. raise the mixture through 1° C.

∴ $212\frac{3}{5}$ T. U. raise the mixture $\frac{25}{59} \times \frac{1063}{5} = 90{\cdot}9°$ C.

Q. 396.—If 1 lb. of iron and 1 lb. of mercury be heated to the same temperature and then put into separate pans A and B, each containing 1 lb. of ice-cold water, which pan will now contain the hotter water? Give clearly the reason for your answer.—M.U., 1884.

Ans. A, the pan into which 1 lb. of iron is put, contains the hotter water. B, the pan in which 1 lb. of mercury at the same temperature is put contains the colder water.

Reason.—The specific heat of iron is ·11 and that of mercury ·03. Therefore, 1 lb. of iron contains more heat than 1 lb. of mercury at the same temperature. Hence, the mixture in A will be hotter than the mixture in B.

Q. 397.—What mass of mercury at 35° C. will be raised by 10° C. by dropping into it 1 lb. of iron at 400° C.?

(N.B.—*Sp. Heat of mercury ·03 and of iron ·11.*)

Ans.—1 lb. of iron falling through 1° C. gives out $\frac{11}{100}$ T. U.

$\therefore$ 1 lb. „ [400—45=] 355° C. „ $\frac{11 \times 355}{100}$ T. U.

[Next, find out what quantity of mercury will be raised through 10° C by applying to it $\frac{11 \times 355}{100}$ T. U.]

To raise 1 lb. of mercury through 1° C. it requires $\frac{3}{100}$ T. U.

$\therefore$ 1 lb. „ 10° C. „ $\frac{3}{10}$ T. U.

$\frac{3}{10}$ T. U. raises through 10° C. mercury weighing 1 lb.

1 „ „ „ $\frac{10}{3}$ lbs.

$\therefore$ $\frac{11 \times 355}{100}$ „ „ $\frac{10}{3} \times \frac{11 \times 355}{100}$

= 130·16 lbs. of mercury. *Ans.*

Q. 398.—A vessel made of iron weighing 15 lbs. contains 10 lbs. of mercury. What would be the rise in temperature by pouring into it 1 lb. of boiling water, assuming that the vessel and mercury were previously at 20° C. (Sp. Ht. of iron ·11 and of mercury ·03)?

Sol.—15 lbs. of iron at 20° C. contains $\frac{15 \times 20 \times 11}{100}$ = 33 T. U.

and 10 lbs. mercury „ „ $\frac{10 \times 20 \times 3}{100}$ = 6 T. U.

and 1 lb. of boiling water contains 100 T. U.

[The question may now be asked thus:—What is the final temperature of a mixture of 15 lbs. of iron, 10 lbs. of mercury and 1 lb. of water, all at 0° C when 100 + 6 + 33=139 units of heat are applied?]

To raise 1 lb. of mercury through 1° C. we require $\frac{3}{100}$

∴ „ 10 lbs. „ „ „ $\frac{3}{10}$ T. U.

„ 1 lb. of iron „ „ $\frac{11}{100}$ T. U.

∴ „ 15 lbs. of iron „ „ $\frac{33}{20}$ T. U.

To raise 1 lb. of water through 1° C. we require 1 T. U.

∴ to raise 15 lbs. of iron, 10 lbs. of mercury and 1 pound of water through one decree we require $\frac{3}{10} + \frac{33}{20} + 1 = \frac{59}{20}$ T. U.

$\frac{59}{20}$ T. U. raise the whole through 1° C.

∴ 1 „ „ „ $\frac{20}{59}$° C.

∴ 139 T. U. „ „ $\frac{23}{59} \times 139 = 54{\cdot}1$° C. *Ans.*

Q. 399.—Define the latent heat of water and of steam. If two similar vessels containing 1 lb. of ice and 1 lb. of water each at 0° C. be placed in a warm room, and if after 10 minutes the temperature of the water is found to be $26\frac{1}{3}$° C., when should the ice be first melted ?—M.U., 1882.

Ans.—Latent heat of water is the quantity of heat required to convert ice at 0° C. into water at 0° C. It is about 79 T. U. for every pound of ice.

Latent heat of steam is the quantity of heat required to convert boiling water into steam at the same temperature. It is about 537 T. U. for every pound.

1 lb. of water at 0° C. rises to $26\frac{1}{3}$° C. after 10 minutes ;

∴ the heat given out by the air in 10 minutes is $26\frac{1}{3}$ T. U.

But to convert 1 lb. of ice at 0° C. into water at 0° C., 79 T. U. are required.

$26\frac{1}{3}$ T. U. are absorbed in 10 minutes. ∴ 79 are absorbed in 30 minutes.

∴ The ice will completely melt after 30 minutes.

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Q. 400.—Calculate the final temperatures in the following two cases:—(1) The heat that can raise 10 lbs. of copper through 100° C. is applied to 25 lbs. of water at 35° C.; (2) 40 lbs. of copper at 100° C. are put into 25 lbs. of water at 35° C. The specific heat of copper is ·09.

Sol.—(1) To raise 1 lb. of copper through 1° C. we require ·09 T. U.

∴ To raise 1 lb. of copper through 100° C. we require $100 \times \cdot 09 = 9$ T. U.

∴ To raise 40 lbs. of copper through 100° C. $= 40 \times 9 = 360$ T. U.

To raise 1 lb. of water through 1° C. we require 1 T. U.

To raise 25 lbs. water through 1° C. we require 25 T. U.

Now, 25 T. U. raise 25 lbs. of water through 1° C.

∴ 360 T. U. raise 25 lb. of water $\frac{1}{25} \times 360 = 14{\cdot}4°$ C.

But the water is already at 35° C.

∴ the final temperature will be $35 + 14{\cdot}4 = 49{\cdot}4°$ C.

(2) 40 lbs. of copper at 100° C. possess 360 T. U.

25 lbs. of water at 35° C. possess $25 \times 35 = 875$ T. U.

Now, the question may be put thus:- To what temperature does a mixture of 40 lbs. of copper and 25 lbs. of water rise if (360 + 875) T. U be applied to it?

25 T. U. raise 25 lbs. of water through 1° C.; and $40 \times \cdot 09 = 3{\cdot}6$ T. U. raise 40 lbs. of copper through 1° C.

Therefore (25 + 3·6) T. U. raise the mixture through 1° C.

∴ (360 + 875) T. U. . . . . $\frac{1235}{28{\cdot}6} = \mathbf{43{\cdot}2°\ C.}$

Q. 401.—Two lbs. of ice at 0° C. is heated till it has all passed off in steam. Compare the amount of heat spent in this case with that required to raise the temperature of 10 lbs. of mercury from 0° C. to 100° C.—M.U., 1883.

Sol. 1 lb. of ice at 0° C. to become water at 0° C. requires 79 T. U.

1 lb. of water at 0° C. to boil requires 100 T. U.

1 lb. of boiling water to pass off as steam requires 537 T. U.

∴ 1 lb. of ice at 0° C. to disappear as steam requires

$537 + 100 + 79 = 716$ T. U.

∴ 2 lbs. . . „ „ . . 1,4 32 T.U.

But to raise 1 lb. of mercury through 100° C. we require $\frac{100 \times 3}{100} = 3$ T. U.

$\therefore$ „ 10 lbs. „ „ 30 T. U.

$\therefore$ The heat required to drive off 2 lbs. of ice at 0° C. as steam is $\frac{1,432}{30}$ times the heat necessary to raise 10 lbs. of mercury through 100° C.

Q. 402.—How much ice at 0° C. would you have to put into 19 ounces of water at 30° C. in order to cool it to 16° C.?—M.U., 1895.

Sol.—The heat given out by 19 ounces of water at 30° C. in falling to 16° C $= \frac{19}{16} \times 14 = \frac{133}{8}$ T. U.

[The question may now be put thus:—What quantity of ice at 0° C. would be converted into water at 16 C. by $\frac{133}{8}$ T. U. ?]

(79+16) or 95 T. U. convert (into water at 16° C.) 1 lb. of ice at 0° C.

$\therefore \frac{133}{8}$ „ $\frac{1}{95} \times \frac{133}{8} = \frac{133}{760}$ lbs. $= \frac{133 \times 16}{760} = 2\frac{4}{5}$ oz. *Ans.*

Q. 403.—How is the specific heat of a body affected by its state? Illustrate your answer by a suitable example.

Ans.—The specific heat of a body is greater in the liquid state than in any other state. Take water for example. To raise 1 lb. of water through 1 degree, one Thermal Unit is required. But to raise 1 lb. of ice through 1 degree (say from −4° C. to −3° C. or from −9° C. to −8° C.) you require only half a Thermal Unit, because the specific heat of ice is ·5. Again, to raise 1 lb. of steam through one degree you require only ·4 of a therma unit. The specific heat of steam is ·4.

Q. 404.—If at the top of Mount Blanc, where the cold is 5° C. below the freezing point, we were to pour 1 lb. of boiling water on 1 lb. of ice, what would be the resulting temperature of the water after the melting of the ice?—M.U., 1884.

Water boils on the top of Mount Blanc at 85° C.

$\therefore$ 1 lb. of *water boiling there* contains 85 T. U.: *of these*—

2½ thermal units are spent in raising 1 lb. of ice from −5° C. to 0° C. (because the cold there is 5 degrees below the zero and the specific heat of ice is ·5, *i.e.*, to raise 1 lb. of ice through one degree below zero requires only half a thermal unit),

and 79 thermal units are spent in converting 1 lb. of ice at 0° C. into 1 lb. of water at 0° C.

∴ Altogether 81·5 thermal units are spent; and 3·5 thermal units remain in the 2 lbs. of water.

∴ Temperature of the water would be $\frac{3{\cdot}5}{2} = 1{\cdot}75°$ C. *Ans.*

Q. 405.—By means of melting ice how could the specific heat of a body be determined?

Ans.—The body whose specific heat is to be determined is weighed; say, it weighs 4 lbs.

It is then raised to a certain temperature; say to 85° C.

Then, it is placed between two blocks of ice. The body loses heat in converting the ice around it into water. The water is collected and weighed: suppose it weighs 2 lbs.

Since the heat in the body has melted 2 lbs. of ice (and since the latent heat of water is 79 T. U.) it is 2 × 79 or 158 T. U.

∴ 4 lbs. of the substance at 85° C contain 158 T. U.

∴ 1 lb. „ 85° C. „ $\frac{158}{4}$ T. U.

∴ 1 lb. „ 1° C. „ $\frac{158}{340}$ T. U.

∴ The specific heat of the body is $\frac{158}{340}$ or ·46 *Ans.*

Q. 406.—What is meant by saying that the specific heat of lead is ·031? Fifty grammes of lead shot at 100° C. are poured into a beaker containing 30 grammes of turpentine at 15° C., and the temperature of the mixture is found to be at 23·4° C. Find the specific heat of turpentine, giving clear reasons for your answer.—Lon. Mat., 1902 September.

Ans.—To raise one pound of lead through one degree centigrade ·031 unit of heat is required [*i.e.*, the heat necessary to raise ·031 lbs. of water through 1° C.

Sol.—Lead shot has fallen from 100° C. to 23·4° C., *i.e.*, through 76·6 degrees, and the turpentine rose from 15° C. to 23·4° C., *i.e.*, through 8·4° C.

1 lb. of lead falling through 1° C. gives out $\frac{31}{1000}$ T. U.

∴ 50 grms. or $\frac{1}{10}$ lb. falling through 76·6° C. gives out $\frac{31}{1000} \times \frac{1}{10} \times \frac{766}{10}$ T. U.

Now, 30 grms. or $\frac{3}{50}$ lbs. of turpentine, in rising through 8·4 degrees absorbs $\frac{31}{1000} \times \frac{1}{10} \times \frac{766}{10}$ T. U.

∴ 1 lb. . . . 1° C. = . . $\frac{31}{1000} \times \frac{1}{10} \times \frac{766}{10} \times \frac{50}{3} \times \frac{10}{84} = \cdot 4$.

Q. 407.—"The latent heat of fusion of ice is 80." Explain this statement. A lead bullet weighing 40 grammes is heated in a test tube surrounded by boiling water and then quickly placed in a cavity in a block of ice. After a few minutes the temperature of the bullet has fallen to 0° C. and 1·5 grammes of ice have been melted. Find the specific heat of lead.—

Lon. Mat., Sept. 1902.

Ans.—Explanation.—To change one pound of ice at 0° C. into water at 0° C., the quantity of heat required is eighty units of heat.

Sol.—To change 1 lb. of ice into water 80 T. U. are required.

∴ To change 1·5 grms. or $\frac{3}{1000}$ lbs. . . . $\frac{80 \times 3}{1000} = \frac{6}{25}$ T. U.

Hence, $\frac{6}{25}$ T. U. have been given out by 40 grms. or $\frac{2}{25}$ lbs. of lead in falling from 100° C. to 0° C.

$\frac{2}{25}$ lbs. of lead falling through 100 degrees give out $\frac{6}{25}$ T. U.

∴ 1 lb. of lead ,, 1 degree gives out $\frac{6}{25} \times \frac{1}{100} \times \frac{25}{2} = \frac{3}{100}$

∴ Sp. Ht. of lead $= \frac{3}{100} = \cdot 03$. *Ans.*

Q. 408.—Compare the heat required to raise 45 lbs. of iron from 35° C. to 225° C. with that given out when 1·5 lbs. of

water at 20° C. are frozen to ice at 0° C. (Sp. Ht. of iron ·1; latent heat of water 79 T. U.)

Sol.—To raise 1 lb. of iron through 1° C. = ·1 T. U.

,, 45 lbs. of iron through 1° C. = 45 × ·1 = 4·5 T. U.

∴ ,, 45 lbs. of iron through (225 — 35) = 190 degrees, we require 190 × 4·5 = 855 T. U.

Next, one pound of water falling through 1° C. gives out 1 T. U.

∴ 1·5 lbs. of water . . . . . 20° C. gives out 30 T. U.

And 1 lb. of water at 0° C. becoming ice at 0° C. gives out 79 T. U.

∴ $\frac{3}{2}$ lbs. of water at 0° C. give out $\frac{79 \times 3}{2} = 118{\cdot}5$ T. U.

∴ 1·5 lbs. of water at 20° C. becoming ice at 0° C. give out

$$118{\cdot}5 + 30 = 148{\cdot}5 \text{ T.U.}$$

∴ The heat required in the 1st case : heat given out in the 2nd case :: 855 : 148·5, *i.e.*, 1710 : 297.

Q. 409.—Name some *natural* phenomena that depend upon both the latent heat and the specific heat of water being greater than those of any other substance.—M.U., 1894.

Ans.—*The specific heat of water being greater,*

(i) the water in seas and rivers does not pass away as vapour on being heated by the sun in summer;

(ii) the climate of countries in the vicinity of great bodies of water is rendered agreeable;

(iii) the sea breeze and the land breeze are also due to the higher specific heat of water than that of *land.*

The latent heat of water being greater,

(i) all the ice on the tops of mountains does not melt at once and flood the country below on the approach of summer;

(ii) all the water in the seas and rivers does not become converted into ice at once on the approach of winter.

Q. 410.—How may it be demonstrated that the temperature at which water boils depends upon the pressure upon its surface? —M.U., 1895.

(2) Take a beaker containing water in which boiling has just ceased. Place it under the receiver of an air-pump. Work the pump. As the exhaustion proceeds, the liquid in the beaker will be seen to boil again. This is because the pressure of the air in the receiver has been reduced.

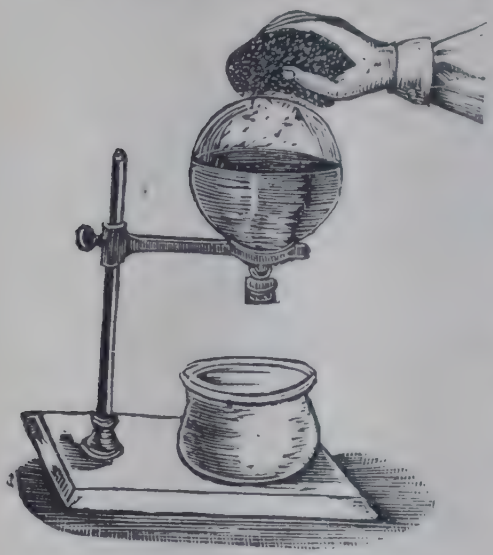

Fig. 52.

(3) Take a flask ; fill about two-thirds of it with water : boil the water. When the water is boiling, cork it and remove the source of heat. The boiling ceases. In the flask there is only water and its vapour, and no air. Now invert the flask and pour cold water over that. (Fig. 52.) Boiling will be seen in the water again. This is because the cold water poured has made the vapour above the water in the flask condense and thus the pressure above the water is reduced. Hence the boiling again.

Q. 411.—(*a*) How would you raise the temperature of water to 100° C. at the top of a high mountain ? (*b*) Describe a method of causing water to boil at 100° C. at the bottom of a deep mine.—M.U., 1886.

Ans.—As the pressure above affects the boiling point of a liquid water on the top of a mountain can be made to boil at 100° C. by increasing the pressure above. This may be done by a sufficiently weighty lid which closes the mouth of the vessel air-tight.

At the bottom of a mine the pressure of the air is greater, and so water boils above 100° C. By diminishing the pressure of the air above the water in the vessel sufficiently, the water may be made to boil at 100° C.

Q. 412.—Describe an experiment to show that liquids are bad conductors of heat compared with solids.—M.U., 1893.

Ans.—Take a long and wide test tube containing ice-cold water. Attach a piece of ice to some heavy substance, say a piece of lead, and drop it into this water. When the ice has reached the bottom of the water in the tube, heat the test tube at its mouth. The water may even be set to

boil away, but the ice at the bottom will not melt. If water were a good conductor, the heat applied at the top would be conducted to the bottom through water and melt the ice.

Q. 413.—When melting ice and salt are mixed together, why is the temperature lower than that of the ice?—M.U., 1885.

Ans.—When a solid is converted into liquid, it absorbs heat. Here ice and salt form a solution. In doing so, the heat required is taken from their bodies also. Hence, the resulting temperature will be lower than that of either.

Q. 414.—A piece of ice can be kept from melting for a much longer time if it be well wrapped in a flannel blanket. Again, a man to keep himself warm on a cold day, wraps himself up in a flannel blanket. Explain the action of the blanket in these two cases—M.U., 1896.

Ans.—Blanket is a bad conductor of heat. In both the cases the principle on which the blanket acts is the same. It prevents the external heat from reaching the ice and melting it. In the case of the man it prevents the escape of heat from his body to the outer air and thus it keeps him warm.

Q. 415.—State and explain the different processes in which a liquid may disappear as vapour.

Ans.—There are two ways in which a liquid may disappear as vapour. In one, the liquid assumes the gaseous form without any noise and goes off as vapour quietly from the surface; while in the other, the liquid escapes as vapour violently in the form of bubbles. The former is known as evaporation, and the latter, ebullition or boiling.

Q. 416.—How does a gas resemble a vapour and how does it differ from it?

Ans. Both a gas and a vapour belong to the same state of matter, but a gas at the ordinary temperature is always in the gaseous and in no other state. Oxygen, air and hydrogen, etc., are examples of gases. Vapour is the gaseous form of a substance which at the ordinary temperature happens to be a liquid or a solid, *e.g.*, (1) vapour of water, (2) vapour of mercury, (3) vapour of alcohol, etc.

Q. 417.—Explain the term 'the boiling point of a liquid' with reference to an example. State the conditions under which liquids may have the same boiling point always.

Ans. 'The boiling point of a liquid' means 'the temperature at which that liquid begins to boil.' 'The boiling point of water is 100° C.' means that water begins to boil at 100° C.

The *same* liquid has the same boiling point, provided *the pressure* above it remains the *same*.

Q. 418.—Explain (1) 'To lower the boiling point of a liquid'; (2) to raise the boiling point of a liquid; (3) the boiling point of a liquid depends upon the pressure above it.

Ans.—(1) '*To lower the boiling point of a liquid*' means 'to make the liquid boil at a lower temperature than the usual one.'

(2) '*To raise the boiling point of a liquid*' means 'to make the liquid boil at a higher temperature than the usual one.'

(3) Means, a liquid boils at a higher temperature, if the pressure above is increased; and it boils at a lower temperature, if the pressure above is decreased.'

Q. 419.—When do you say that a liquid boils? How does evaporation differ from ebullition?

Ans. We say that a liquid boils, only when we see rapid production of bubbles of vapour in the liquid.

Evaporation is the slow production of vapour from the surface of a liquid, and it takes place at all temperatures.

Ebullition is the rapid production of bubbles of vapour even in the interior of a liquid, and this takes place only at one temperature so long as the liquid is the same and so long as the pressure above it is the same.

Q. 420. State the conditions which affect the rate of evaporation from the surface of a liquid.

Ans. (1) *Temperature.* As the temperature rises, evaporation takes place more and more quickly.

(2) *Currents of winds.* Evaporation takes place more quickly in the presence of currents of winds.

(3) *Presence of similar vapour in the air.*—If the air contains more vapour, then evaporation from the surface of that liquid will be slower

(4) *Nature of the liquid.*—Some liquids, such as alcohol, evaporate more quickly than others, such as water, etc.

Q. 421.—Give reasons for the following facts :—

(1) Fanning cools hot water.

(2) Wet clothes do not dry up soon in rainy days.

Ans. (1) Currents of wind hasten evaporation. Evaporation takes place at the expense of the heat in the liquid. Hence, the liquid cools soon.

(2) In the rainy season the air cannot take up as much vapour of water as in other seasons. Hence, evaporation of water cannot take place quickly. So, the wet cloth does not dry up soon.

Q. 422.—How is the rain caused ?

Ans.—Evaporation takes place from the surface of great bodies of water, such as seas, rivers, etc., on a large scale in nature. Vapour of water is lighter than the air, bulk for bulk : therefore the air mixed with the vapour of water is also lighter and rises up. Coming into contact with colder regions above, it becomes cooled below the point of saturation and gives up the vapour, which becomes condensed and becomes visible as a *cloud*. When the particles composing the cloud unite together and become sufficiently large drops, they come down as rain.

Q. 423.—Explain how clouds, rain, hail, snow, mist, fog and dew are due to the same cause, and how they differ from one another.

Ans. All these are due to the condensation of the vapour of water in the air, but under different conditions.

Clouds. When vapour is condensed at higher regions it appears as clouds.

Rain. When the particles in the clouds join together and become bigger drops, they come down as rain.

Snow. If the rain *before coming down* is cooled so much as to become frozen, it falls down as snow.

Hail. When rain passes through very cold regions, it changes into solid and comes down as hail.

Mist. When the vapour of water is condensed on the tops of mountains you have mist.

Fog. Sometimes the vapour of water in the air becomes condensed and remains suspended in the air. It is then known as *fog*.

Dew.—Early in the morning we see drops of water on leaves, grass, etc. This is due to the vapour of water in the air deposited as drops during the previous night, and is called '*dew*.'

Q. 424.—State the Laws of Ebullition.

Ans.—(1) So long as the pressure above remains unchanged, a given liquid boils only at one temperature.

(2) Different liquids have different boiling points.

(3) Salt dissolved in a liquid raises its boiling point.

(4) After a liquid reaches the temperature of ebullition, it does not rise in temperature any more, though the heat be continued.

Q. 425.—By what names is *water* known in its different states? What are the peculiarities of it in each of those states?

Ans.—In the solid state it is known as ice. When water becomes ice it expands. Ice being thus lighter than water, bulk for bulk, it floats on water.

In the liquid state, it is known as water. It acts in accordance with the general rule 'that bodies expand by heat' only when above 4° C., but below temperature, it behaves as an exception to that rule. It dissolves a greater number of solids than any other liquid.

In the gaseous state, it is known as steam. The expansive force of steam is very great and, hence, it is used to propel engines, etc. One cubic inch of water occupies *in the state of steam* nearly 1,700 cubic inches of space. Steam has in it a great quantity of heat that cannot be observed by a thermometer.

Q. 426.—Independently of direct measurements, what other means have we got of measuring the heights of mountains?

Ans.—(1) *Barometers.*—The higher we go, the column of atmosphere gets less and less. Consequently, the pressure exerted by the atmosphere gets less and less, the higher we ascend. This diminished pressure affects the barometric column, and it gets shorter. A fall of one inch in the mercurial column of the barometer corresponds to a height of about 900 feet. The fall of the column in the barometer will not, however, be proportional to the height ascended, because the density of the atmosphere decreases more rapidly at higher latitudes. Hence, a fall of another inch in the barometer will take place for an ascent of 1,000 feet, and the fall of a third inch, for an ascent of 1,100 feet. Thus, by noting the fall in the barometric column, the height ascended may be determined.

(2) *Thermometers.*—Water boils at a lower temperature under reduced pressure. This has been proved by such experiments as (i) pouring cold water over a flask containing water in which boiling has just ceased, (ii) Working an air-pump, under the receiver of which is placed a flask containing water in which boiling has ceased. In both of which cases the water commences boiling again. It has been calculated that an ascent of *certain* height reduces the boiling point by a certain number of degrees. Therefore, by making water boil at the given place and noting the boiling point, we may be able to determine the height of the place above the sea-level.

(3) Again, the higher we go the cooler does the atmosphere become. So, a thermometer falls as we go higher and higher. It has been found that 'an ascent of 540 feet corresponds in the mean to a diminution in the average temperature of 1° C. in the temperate zone'.

Q. 427.—When a piece of wood and a piece of iron are at a temperature of 50° C., the iron feels hotter than the wood. Explain the cause of this, and describe an experiment by which your answer can be justified.—M.U., 1903.

Ans.—Iron is a better conductor than wood. Good conductors pass on heat better than bad conductors. The hand, therefore, receives heat quicker from the iron than from the wood, though both of them are at 50° C. Hence, the iron at 50° C. feels hotter than wood at 50° C.

Expt.—Four bars of different metals are so fixed that they meet in the centre upon a ring of wood, and these bars have cups for receiving phosphorus or some other inflammable substance at equal distances from the centre. (See fig. 53.) Phosphorus is placed in these cups and the bars are heated by a spirit lamp at the place of their junction. All the bars now conduct the heat, and that bar in which the phosphorus takes fire first is the best conductor, and the rest come next in order according to the time at which the phosphorus in their cups takes fire. This experiment shows that different solids conduct heat differently.

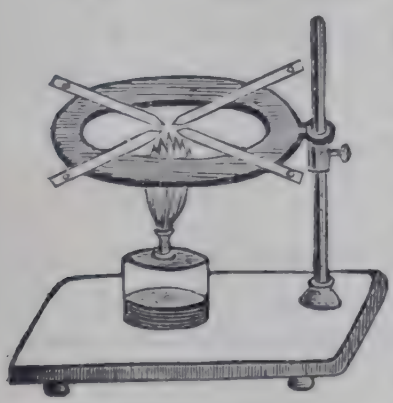

Fig. 53.

Q. 428. A block of ice is fixed at the bottom of a vessel, which is then filled with water up to a certain level. Will the

surface of the water remain at the same level after the ice melts?—M.U., 1888.

Ans.—No. It will be a little lower than before. Because, when ice melts it contracts and occupies a smaller volume in the form of water.

Q. 429.—A piece of red-hot iron is placed under the receiver of an air-pump and the air then exhausted. Will a thermometer at a small distance from the receiver be affected? Give reason for your answer.—M.U., 1884.

Ans.—Heat does not require a material medium to be propagated. Therefore, the absence of air in the receiver does not prevent the propagation of heat. The thermometer '*at a small distance*' from the red-hot iron in the receiver will be affected and will be seen to rise, because heat can pass through vacuum as well as glass.

Q. 430.—Give some instances of the fact that bad conductors resist the passage of heat through them.

Ans.—(i) Ice is kept in saw-dust to prevent melting. Saw-dust is a bad conductor of heat for two reasons: first, because wood is a bad conductor; and, secondly, because the spaces between the saw-dust contain air which also is a bad conductor. The saw-dust, therefore, prevents the external heat from reaching and melting the ice. (ii) "Lava (melted rock which rushes out through volcanoes) has been known to flow over a layer of ashes, underneath which was a bed of ice, without melting the ice." (iii) Two shirts are warmer than one of same material but of double the thickness. In the former case there is a layer of air between, which is a bad conductor of heat. (iv) Clothes make us warm, not because they are warm themselves, but because they prevent the warmth of the body from going out, being bad conductors.

Q. 431.—A lighted candle, when placed in a tall glass vessel closed at the top, all except a small hole, goes out. But if the hole is divided by means of a slip of cardboard, the candle will continue to burn. Explain this.—M.U., 1892.

Ans.—In the first case there is only one way for the carbon dioxide to escape and the outside air to get in. The result is that the flame is surrounded by carbon dioxide in a short time. Hence the flame goes out. In the second case there is one way for the air to get in and another for

the carbon dioxide to go out. Through one part of the hole the outside air gets in, and through the other, the carbon dioxide formed goes out. Hence, the candle continues to burn.

Q. 432.—Some ice at 20° F. is pounded and placed in a beaker and the beaker is placed in a vessel containing hot water. The pounded ice is stirred by means of a graduated glass thermometer. Describe carefully what takes place.—M.U., 1902.

Ans.—The thermometer gradually rises in temperature till it reaches 32° F. Then the thermometer stops rising and the ice begins to melt. When all the ice has melted, the thermometer begins to rise and continues to rise till the water reaches the same temperature as that of the water in the vessel. During the process, the temperature of the water in the vessel falls.

After reaching 32° F. the ice in the beaker begins to melt and become water. It contracts in volume when becoming water; the water formed continues to contract till it reaches $39\frac{1}{5}$° F. and afterwards it begins to expand.

Q. 433.—Explain the use of a glass chimney round the flame of a lamp. Give in a general way the physical cause of winds.—M.U., 1890.

Ans.—(1) The glass chimney protects the flame from currents of winds. (2) It enables the flame to be in a steady current of air. As the heated air ascends, the outside air enters into the chimney from below. The flame is thus kept steady. The carbon particles are raised to incandescence thereby, and these render the flame brighter.

Winds are only the convection currents set up in the atmosphere owing to the unequal temperatures of the adjacent localities. "The air next to the hotter place expands more and becomes lighter and ascends. To take its place, the air from the neighbouring part rushes in. Thus a wind is caused. When two neighbouring regions are at different temperatures, a current of air flows from the colder to the warmer in the lower strata and in the upper strata a current flows from the warmer to the colder."

Q. 434.—In what three ways may a cold body receive heat from a hot body?—M.U., 1884.

Ans.—Conduction, Convection and Radiation.

Q. 435.—Describe the different ways in which a hot body may part with its heat to a cold body.—Lon. Mat., 1901.

Ans.—(1) *Conduction.*—The process by which heat is transmitted in solids is called conduction. In this process the body comes into contact with the source of heat and that part of it which is in actual contact with the source of heat receives the heat energy first and imparts it to the adjacent particles, which in their turn do the same and the heat is thus distributed in the body. Each particle, therefore, remains in its own place and receives the heat-energy from the neighbouring particles, which from their adjacent particles, and these ultimately from the source of heat.

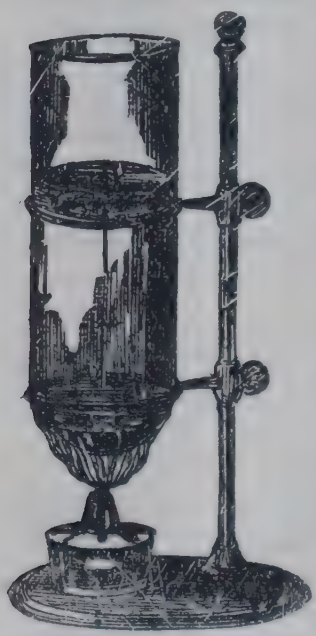

Fig. 54.

(2) *Convection.*—In this process the particles of the body change their places and come into contact with the source of heat and become heated. The layers that are nearer the source of heat are heated first, expand, become lighter, and ascend. Their place is taken by the layers above. Fig. 54.

(3) *Radiation.*—The way in which heat is propagated through spaces without any material medium is said to be *radiation.* In this process the heat is supposed to be propagated by means of waves set up in ether, which pervades all space.

Q. 436.—If a vessel containing hot water is placed under the receiver of an air-pump, and the air rapidly exhausted, state what will happen. Will the water become hotter or colder and why?—Pun. Ent., 1900.

Ans.—Under a reduced pressure water (or any other liquid) can boil at a lower temperature than its usual boiling point. Hence when the pressure under the receiver of the air-pump has been sufficiently reduced, the water in the vessel begins to boil.

The water becomes colder. The boiling takes place at the expense of the heat in the water. Hence, the temperature of it falls, *i.e.*, it becomes colder.

Q. 437.—What is meant by conduction of heat? Explain carefully why when water is boiled in an egg-shell the shell is not injured by the fire.—Pun. Ent., 1900.

Ans.—Conduction is the process whereby heat is propagated in solids; and in this process the particles do not change their places. The various particles in contact with the source of heat receive the heat-energy first and transmit it to their neighbouring particles, and these to their neighbouring particles, and so on, till at last the remotest parts of the body also receive heat-energy.

When water is boiled in an egg-shell the heat applied is spent in heating the water. The shell is heated and the heat in passed on to the water inside. Thus the shell is not heated to such a degree that it is injured.

Q. 438.—(*a*) Explain how you would determine the latent heat of steam. (*b*) A ball of copper, weighing 10 lbs. and heated to 110° C., is placed in melting ice. Find how much ice will be converted into water (the sp. heat of copper = ·09.)—

Pun. Ent., 1902.

Ans.—(*a*) A certain known weight of water is to be taken. Its temperature is to be observed. Some water is to be heated in another vessel. When this water is actually boiling, the steam issuing from it is to be passed, by means of a tube, into the water the weight and temperature of which have been determined. The steam passing into this water condenses, raises its temperature and increases its weight. By noting this additional weight and temperature the latent heat of steam can be determined.

Suppose the original weight of water = 1,000 ounces.

Suppose the original temperature = 10° C.

Temperature at the end of the experiment = 20° C. Water distilled over and condensed = 16·3 ounces.

∴ the quantity of heat absorbed by the 1,000 oz. of water in rising from 10° C. to 20° C. $= \frac{1000 \times 10}{16} = 625$ T. U.

∴ the latent heat of 16·3 oz. of steam, together with the heat given out by its falling from 100° C. to 20° C. is 625 T. U.

16·3 oz. of water in falling from 100° C. to 20° C. gives out $\frac{16{\cdot}3 \times 80}{16}$

$= 81{\cdot}5$ T. U.

$\therefore$ the latent heat of 16·3 oz. of steam = 625—81·5 = 543·5 T. U.

$\therefore$ the latent heat of 1 lb. of steam = 533 T. U.

(*b*) *Sol.*—1 lb. of copper at 1° C. contains ·09 T. U.

$\therefore$ 10 lbs. copper at 110° C. contains (·09 × 10 × 110) T. U.

But 80 T. U. change 1 lb. of ice into water.

$\therefore$ (·09 × 10 × 110) T. U. change 1·2 lbs. of ice into water.

Q. 439. What weight of steam at 100° C. when passed into a mixture of 4 lbs. of ice and 2 lbs. of water at 0° C. contained in a copper vessel (weight 5 lbs.; Sp. Ht. ·09), convert the mixture into water at 50° C.?

Sol.—Let us, first, ascertain the heat necessary to raise the whole mixture to 50° C.

5 lbs. of copper to raise through 50° C. requires 5 × ·09 × 50 = 22·5 T. U.

2 lbs. of water at 0° C. to become water at 50° C. = 2 × 50 = 100 T. U.

4 lbs. of ice to melt and become water at 50° C. = (4 × 79 + 4 × 50) = 516 T. U.

$\therefore$ We require,, in all, (22·5 + 100 + 516) = 638·5 T. U.

This heat must be obtained from steam becoming water at 50° C.

1 lb. of steam at 100° C. in becoming water at 50° C. gives out 537 + 50 = 587 T. U.

587 T. U. are obtained from 1 lb. of steam.

$\therefore$ 638·5 T. U. . . . . $\frac{638{\cdot}5}{587}$ = 1·1 lbs. of steam nearly

Q. 440. Calculate the final temperature when one pound of steam at 100° C. is passed into an iron vessel (weight 4 lbs.) containing 5 lbs. of ice and 5 lbs. of water at 0° C. [Sp. Ht. of iron ·1; latent heat of water 79; of steam 537].

Sol.—1 lb. of steam if converted into water at 0° C. gives out 537 + 100 = 637 T. U. Now, the question may be put thus:—What will be the temperature assumed by a mixture of five lbs. of ice and (5 + 1) = 6 lbs. of water at 0° C. contained in an iron vessel weighing 4 lbs. if 637 T. U. are applied to it.

Five pounds of ice at 0° C. to become water at 0° C. absorb $5 \times 79 = 395$ T. U.

Now, we have 637 − 395 = 242 T. U. distributed over 11 lbs. of water and 5 lbs. of iron.

1 lb. of iron rising through 1° C. absorbs ·1 T. U.

∴ 4 lbs. iron rising through 1° C. absorbs ·4 T.U. and 11 lbs. of water rising through 1° C absorb 11. T. U.

∴ 11·4 T.U. raise the mixture through 1° C.

∴ 242 T. U. raise the mixture $\frac{242}{11{\cdot}4} = \mathbf{21{\cdot}2}$° **C.** nearly.

Q. 441.—Why does water freely exposed in a shallow vessel evaporate much more slowly in the rains than in the cold weather?—Cal. Un., 1891.

Ans.—The rate of evaporation from the surface of a liquid depends upon the presence of similar vapour in the air. During the rainy season the atmosphere will have a larger quantity of vapour of water than in the cold weather. Hence, the water evaporates more slowly in the rains than in the cold weather.

Q. 442.—The specific heat of mercury is ·03. A pound of steam at 100° C. is made to pass into a vessel containing 30 lbs. of mercury at 0° C., the capacity for heat of the vessel being equal to that of 10 lbs. of water. What will be the final temperature?—Lon. Mat., 1885.

Ans.—A pound of steam at 100° C. = a pound of water at 0° C. + 637 T. U.

[The question may now be asked thus:—What would be the final temperature, if 637 T. U. be applied to a mixture of 30 lbs. of mercury and (10+1) lbs. of water at 0° C.?]

To raise the mixture through 1° C., you require $\left(\frac{30 \times 3}{100} + 10 + 1\right)$

$$= 11\frac{9}{10} \text{ T. U.}$$

$\frac{119}{10}$ T. U. raise the mixture through 1° C.

∴ 637 T. U. ,, $\frac{10}{119} \times 637 = 53\frac{1}{2}$° C. nearly. ***Ans.***

Q. 443.—1 lb. of ice at 32° F. is put into a vessel (A) containing 10 lbs. of water at 65° F.: and 1 lb. of water at 32° F. is poured into a vessel (B) containing 10 lbs. of water at 65° F. Describe carefully what happens in these two cases, supposing the vessels (A) and (B) neither to lose nor gain heat.—M.U., 1902.

Sol.—(*a*) 32° F. = 0° C.: 65° F. = $18\frac{1}{3}$° C.

10 lbs. water at $18\frac{1}{3}$° C. contains $183\frac{1}{3}$ T. U.

Of these 79 T. U. are spent in converting 1 lb. of ice into water at 0° C.

∴ $183\frac{1}{3} - 79 = 104\frac{1}{3}$ T. U. remains in 11 lbs. of water.

∴ the temperature is $104\frac{1}{3} \div 11 = \frac{313}{33}$° C = $49\frac{4}{55}$° F. *Ans.*

(*b*) 10 lbs. of water have $183\frac{1}{3}$ T. U.

1 lb. of surface ice at 0° C.

∴ 11 lbs. of [illegible] have $183\frac{1}{3}$ T. U.

∴ the temperature is $183\frac{1}{3} \div 11 = 16\frac{2}{3}$° C. = 62° F. *Ans.*

Q. 444.—Eight pounds of copper wire at 130° C. are placed in 40 lbs. of water at 20° C. After the temperature has become uniform it was found that the water rose by 2 degrees. Find the specific heat of copper.

Sol.—The copper fell from 130° C. to 22° C.: and the water rose from 20° C. to 22° C.; the water thus gained $40 \times 2 = 80$ T. U.

∴ 8 lbs. of copper falling through (130—22 =) 108° C. gave out 80 T. U.

∴ 1 lb. of copper falling through 1° C. gives out $\frac{80}{8 \times 108} = \frac{5}{54}$ T. U.

∴ Sp. Ht. of copper is $\frac{5}{54}$ or ·09. *Ans.*

Q. 445.—What weight of gold at 45° C. will raise 15 lbs. of water from 12° C. to 13·5° C., when placed in it? Specific heat of gold ·032.

Sol.—To raise 15 lbs. of water from 12° C. to 13·5° C. we require $15 \times 1\frac{1}{2} = 22\frac{1}{2}$ T. U.

The question now is, what weight of gold falling from 45° C. to $13\frac{1}{2}$° C. gives out $22\frac{1}{2}$ T. U.?

1 lb. of gold falling from 45° C. to $13\frac{1}{2}$° C. gives out $\left(31\frac{1}{2} \times \frac{32}{1.000}\right)$ T. U.

$\left(\frac{63}{2} \times \frac{32}{1000}\right)$ T. U. are given out by 1 lb. of gold.

$\therefore$ $22\frac{1}{2}$ T. U. . . . . $\frac{2000}{63 \times 32} \times \frac{45}{2} = 22\frac{1}{8}$ lbs. nearly.

Q. 446.—A mass of iron weighing 25 lbs. at 50° C. is placed in 30 lbs. of water at 10° C. Find out the resulting temperature, if the specific heat of iron is ·11.

Sol.—25 lbs. of iron at 50° C. has $\frac{25 \times 50 \times 11}{100} = \frac{275}{2}$ T. U.

30 lbs. of water at 10° C. has 300 T. U.

$\therefore$ when mixed together, $\left(\frac{275}{2} + 300\right)$ T. U. will be distributed over the mass of 30 lbs. of water and 25 lbs. of iron.

But, 25 lbs. of iron to be raised through 1° C. requires $\frac{25 \times 11}{100} = \frac{11}{4}$ T. U.

and 30 lbs. of water to raise through 1° C requires 30 T. U.

$\therefore$ $32\frac{3}{4}$ T. U. raise the mixture through 1° C.

$\therefore$ $300 + \frac{275}{2}$ T. U. raise the mixture $\frac{4}{131} \times \frac{875}{2} = 13\frac{1}{3}$° C. nearly.

Q. 447.—What weight of steam at 100° C. is necessary to raise the temperature of 104 lbs. of water from 20° C. to 50° C., the latent heat of steam being 537?

Sol.—Steam at 100° C. in becoming water at 50° C. raises 104 lbs. of water from 20° C. to 50° C., *i.e.*, must give out 104×30 T. U.

1 lb. of steam in becoming water at 50° C. gives out $537 + 50 = 587$ T. U.

Hence, 587 T. U. are given out by 1 lb. of steam in becoming water at 50° C.

$\therefore$ 104×30 T. U. are given out by $\frac{104 \times 30}{587} = 5\frac{1}{3}$ lbs. nearly. *Ans.*

Q. 448.—Why does the balloon rise in the air and what does it consist of? How high can a balloon rise? What is an air-balloon?

Ans.—A balloon rises in the air, because the thing taken as a whole is lighter than an equal volume of the air. It consists of an immense bag of silk filled with hydrogen. (Fig. 55). It rises to a height where the air is so less

in density that the balloon as a whole is of the same weight as an equal volume of the air.

An air-balloon is a balloon which is made to rise in the air with the help of hot air. It consists of a large and light paper bag filled with hot air. Hot air being lighter than cold air, bulk for bulk, makes the bag rise in the air; a fire is maintained inside to produce hot air continuously. At one time people used these balloons to rise into the air.

Q. 449.—Account for the name, the origin, and the direction of the trade winds.

Ans.—Name.—These are so called on account of their uniform course. (Anglo-Saxon, *tredde-wind*, i.e., wind of one uniform track.)

Origin.—These are the currents of winds that blow always in the equatorial regions. In the Northern Hemisphere—that part of the world to the north of the equator—they blow from north-east to south-west, and in the Southern Hemisphere from south-east to north-west. The cause of the winds is this—the equatorial regions are hotter than other parts of the world, and consequently there is continual ascent of the heated air from these parts; to take its place the air from the colder regions rushes in. Hence, the currents of wind from the Poles towards the Equator.

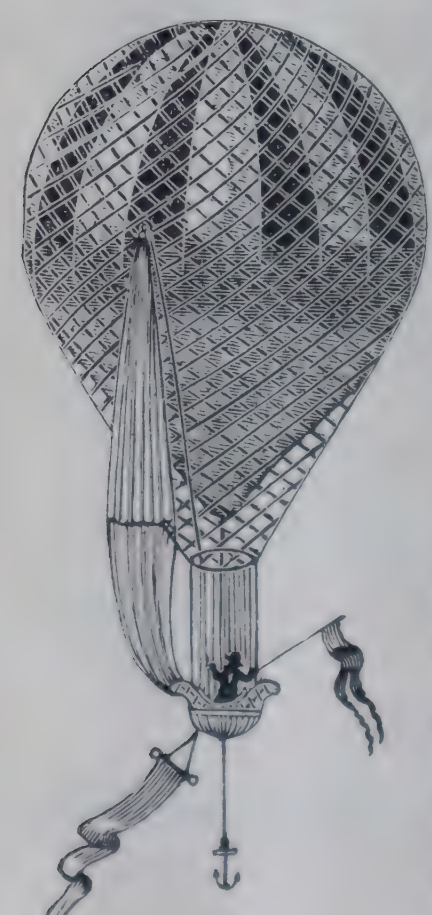

Fig. 55.

Direction.—If the earth were at rest the winds blowing in the two hemispheres would blow directly towards the equator without undergoing any change in their direction. But the earth rotates on its axis from west to east once in every 24 hours. Within this time things on the earth, whether at the Equator or at the Poles, follow the earth's motion, the things at the equator going over a greater distance than the things at the poles. Take, for example, the things A, B and C, at different parts of the world. A on the equator, C near the poles, and B somewhere midway between. Within the 24 hours C goes over the

least distance and A the greatest. Therefore C travels with the least velocity and A with the greatest speed—in other words, things nearer the equator have greater velocity than the things farther from it. Hence, the air that blows from the poles blows from a place of less velocity to a place of greater velocity. In the North Pole for example the air tries to go to the equator straight, but as it goes down, it cannot keep pace with the things there, and lags behind—that is, it is displaced towards the west. The air at the North Pole, therefore, in trying to go to the equator is displaced towards the west, *i.e.*, it blows from N.E. to S.W. Similarly, the wind that blows in the Southern Hemisphere will be from S.E. to N.W.

UNANSWERED QUESTIONS.

Q. 450.—Explain clearly how you may ascertain approximately the height of a mountain either by a barometer or by a thermometer.—M.U., 1904. (Cf. Q. 425).

Q. 451.—If a thermometer graduated at the top of a mountain be placed in the same room with another graduated at the sea-level, which will give the higher reading?

Q. 452.—A tall cylindrical glass vessel filled with water at an ordinary temperature stands on a table and two thermometers are inserted in the water, one near the bottom and the other at the top. A freezing mixture is then placed like a belt round the outside of the vessel about half way up. Which of the thermometers will just begin to fall and which will reach the freezing point first?—M.U., 1876.

Q. 453.—Describe an experiment in which the application of cold water makes water that has ceased to boil, begin boiling again. What would be the effect of pouring boiling water on the flask immediately after the cold and why? What fact is proved by this experiment?

Q. 454.—Give two instances in which heat is communicated to a body without increasing the temperature.—M.U., 1875.

Q. 455.—An experimenter works a pair of bellows and brings first the bulb of a delicate thermometer and afterwards his hand near to the nozzle of the bellows while the air is rushing out. How is it that the thermometer rises during the experiment while the hand feels chilled.

Q. 456.—How is it that a thermometer placed under the receiver of an air-pump always falls as soon as the pump is worked?

UNANSWERED QUESTIONS—*continued.*

Q. 457.—When ammonia gas is passed into water, by which it is eagerly absorbed, the water becomes extremely hot. On the other hand when the gas is allowed to escape from the solution, the temperature falls considerably. Explain both observations and give other illustrations of the principles involved.

Q. 458.—When water and sulphuric acid are mixed together, the mixture becomes hot. When snow and salt are mixed together, a very cold solution is obtained. Account for the production of heat in the former case and cold in the latter—M.U., 1878.

Q. 459.—Water boils at 100° C. and mercury at 350° C.: but if 1 lb. of water and 1 lb. of mercury be heated in similar vessels over the same lamp, the mercury boils first. Explain this.

Q. 460.—One afternoon in winter, when the temperature is about 7 degrees of Fahrenheit scale above the freezing point a hollow iron shell is filled with water and closed by a stout plug. What will happen if the temperature now rises, and what, if it falls? —Loewy's Physics.

Q. 461.—What effect has the opening of a soda-water bottle on the temperature of the liquid?

Q. 462.—Explain the way in which rain is produced from the beginning of its formation to the end.

Q. 463.—By what means could you produce ice artificially without the aid of a freezing mixture.—B.U., 1901.

Q. 464.—Give some illustrations of the principle that whenever any of the effects which heat can produce are reversed, heat itself is the result.

Q. 465. (*a*) How is the barometer affected by variations of temperature? Why would a water-barometer be more affected by such variations than a mercurial one?

Q. 466.—Explain the singing of a tea kettle.

Q. 467.—Explain carefully how a mercurial thermometer is graduated. Describe how a thermometer tube is filled with mercury and give reasons for the method adopted.—M.U., 1902.

Q. 468.—What is a thermometer used for? What are the properties of bodies upon which the action of a common thermometer depends.—M.U., 1899.

Q. 469.—Describe a mercurial thermometer and state how it is constructed. The absolute zero point is 273° C. Express this in F —B.U., 1899.

Q. 470.—Describe a mercurial thermometer. Why is mercury the best liquid for thermometrical purposes? What are the ordinary limits to the employment of mercurial thermometers? Is it possible to construct mercurial thermometers for temperatures higher than the boiling point of mercury?—B.U., 1899.

Q. 471.—A hot iron ball is put in the scale pan of a balance and counterpoised. Will the balance be disturbed as it cools down? Account for your answer.

Q. 472.—How do you account for the name 'Fixed Points'?

Q. 473.—The normal temperature of man is 98·4° F. What is the corresponding temperature by the centigrade scale?

Q. 474.—Explain why a piece of steel floats over molten steel.

Q. 475.—Does water always expand when heated and contract when cooled? Explain the importance of its behaviour in this respect in nature.

Q. 476.—The temperature of the water in a basin is 38° C. The Centigrade and Reaumur's thermometers are placed in it. What would be their readings?

Q. 477.—Which is heavier—a gallon of water at 34° F. or a gallon of water at 20° R? Account for your answer.

Q. 478.—A vessel is filled with water and heated; state and explain what happens.

Q. 479.—Explain why a heated glass chimney cracks when drops of water fall on it.

Q. 480.—An empty vessel is heated and inverted over water. Explain what happens as the vessel cools.

Q. 481.—A, B and C have temperatures of 120° F., 45° C. and 40° R respectively. Which of them has the highest temperature?

Q. 482.—Ten miles of steel rails are welded into one length. How much would they expand if free to do so in changing from 0° C. to 20° C., the co-efficient of linear expansion of the steel being 0·00011? —Lon. Mat., 1903.

Q. 483.—Does ice contract or expand when it becomes water? Describe an experiment to show this.—M.U., 1902 R.

Q. 484.—A glass tube with a bulb at one end and open at the other is put vertically over a glass vessel containing water so that the open end

UNANSWERED QUESTIONS—*continued.*

of the tube is under the surface of the water. Describe and explain what is observed when the bulb is heated and then allowed to cool.—M.U., 1901.

Q. 485.—Why is a Centigrade thermometer so called? Describe how its fixed points are determined.—M.U., 1900.

Q. 486.—How will you show that water is at its maximum density at 4° C.?—B.U., 1898.

Q. 487.—Write down the points of difference between evaporation and ebullition.—Pun. Ent., 1903.

Q. 488.—State the difference between a vapour and a gas, and give two examples of each.

Q. 489.—How does the boiling point of a liquid differ from the Boiling Point on the thermometer?

Q. 490.—After bathing you feel chill if wind blows over your wet body. Why is that?

Q. 491.—How does fanning cool hot tea or coffee?

Q. 492.—State the circumstances in which boiling takes place at a lower temperature.

Q. 493.—Describe an experiment to show how rain is caused.

Q. 494.—What is water called in other states and what are its uses and peculiarities in the different states? Describe experiments to verify your answer.

Q. 495.—The boiling water on the top of Mount Blanc does not enable us to have tea in all its flavour. Why is that so?

Q. 496.—Water, in which boiling has just ceased, is placed under the receiver of an air-pump and the air exhausted. Describe what takes place and account for it.

Q. 497. Which is hotter, the water boiling on the top of a mountain or at its foot?

Q. 498. What would happen if a vessel containing water at 80° C. were placed under the receiver of an air-pump and the air exhausted?—M.U., 1898.

Q. 499.—If I set a cupful of boiling water on the plate of an air-pump, cover it with the receiver, and proceed to exhaust air from within the receiver, what effect will be produced on the hot water? Explain the reason of this.—M.U., 1881.

Q. 500.—A pound of water at 0° C. and a pound of water at 100° C. are taken and heated separately over similar flames. Describe the change and the extent of the change that will have occurred in the latter by the time that the former reaches the temperature of 100° C.—M.U., 1896.

Q. 501.—State some exceptions to the law that 'Heat expands bodies,' and explain the importance of these exceptions in nature and in the arts.—M.U., 1896.

Q. 502.—In laying a railway line, the Engineer leaves a space between the ends of rails. Why is this done? How could you calculate what space should be left?—M.U., 1883.

Q. 503. How would you show that water and air expand at different rates under the action of heat?—M.U., 1895.

Q. 504.—By what experiments could you show that when ice melts (1) it contracts and (2) it absorbs heat?—M.U., 1900.

Q. 505.—Describe and explain two methods of finding the height of a mountain.—M.U., 1900 [Q. 425.]

Q. 506.—Explain fully how the height of places may be determined by noting the boiling point of water.—Cal. U., 1902.

Q. 507.—Describe carefully how to construct a common thermometer. —Lon. Mat., 1899 Jan.

Q. 508. Describe how you would show that different liquids have different co-efficients of expansion with temperature.—Lon. Mat., 1899 Jan.

Q. 509.—What changes occur when ice is heated to 0° C.? When it is heated above 0° C.? When water is raised to 4° C.? When it is raised to 100° C.? When steam is heated to 200° C.?—Lon. Mat., 1900 June.

Q. 510.—Distinguish between vapour and cloud. Is the material in a cloud in the solid, the liquid, or the gaseous state? Give reasons for your answer.—Lon. Mat., 1901 Jan.

Q. 511. To what temperature should a substance (specific heat ·4) be raised, if 40 lbs. of it when placed in 55 lbs. of water is to raise its temperature from 13° C. to 16° C.?

Q. 512.—One pound of iron at 50° C. is placed in 1 lb. of water at 0° C. Contrast the effect with that produced by adding 1 lb. of water at 50° C.

Q. 513.—A ball of lead at 100° C. is placed in an iron vessel weighing 1 lb. and containing 2 lbs. of water at 15° C. After the experiment the temperature of the ball, the water and the vessel was found to be 21° C. Find the weight of the ball (specific heat of lead ·031 and iron ·11).

UNANSWERED QUESTIONS—*continued.*

Q. 514.—Explain how you could illustrate experimentally the general law that liquids expand more than solids when heated.—M.U., 1903.

Q. 515.—Distinguish between convection and conduction of heat; give some illustrations of convection from nature.—Cal. U., 1902.

Q. 516.—By what experiment could you show (*a*) that copper conducts heat better than iron; (*b*) that iron gives out more heat than an equal mass of copper would do in cooling through the same given range of temperature?—Lon. Mat., 1901.

Q. 517.—What mass of mercury at 0° C. will be raised by 5° C. by dropping into it 150 lbs. of iron at 400° C.? (Specific heat of iron ·1 and of mercury ·03).

Q. 518.—Find the specific heat of a substance 80 lbs. of which at 100° C. when immersed in 200 lbs. of water at 10° C., give a resulting temperature of 20° C.

Q. 519.—16 lbs. of sand (specific heat 2) at 75° C. and 20 lbs. iron at 45° C are thrown into 50 lbs. of water at 4° C. Find out the resulting temperature.—Prof. Everet.

Q. 520.—Two ounces of steam at 100° C. is passed into 18 oz. of water at 0° C. and the result was 20 oz. of water at 97° C. Calculate from this the latent heat of steam.

Q. 521.—Calculate the amount of heat necessary to convert 8 lbs. of ice at 0° C. into water at 10° C.

Q. 522.—What will be the resulting temperature if 6 lbs. of water at 90° C. and 4 lbs. of ice at 0° C. are mixed together

Q. 523.—Ten pounds of iron at 500° C. are placed between two blocks of ice at 0° C. Calculate how much of the ice would have been converted into water by the time the iron becomes as cold as ice. (Specific heat of iron ·11.)

Q. 524.—Suppose that it requires 80 times as much heat to melt one ton of ice as would be required to warm one ton of water one degree centigrade, how much of the ice would be melted by pouring into a cavity in its surface 1 gallon of boiling water? (A gallon of water weighs 10 lbs.) —L.U., 1899 Jan.

Q. 525.—Find what would be the result of mixing 3 lbs. of mercury at 100° C. with 1 lb. of ice at 0° C., explaining the steps of your calculation. The specific heat of mercury is ·03.—M.U., 1901.

Q. 526.—Some pieces of melting ice are put into a flask and heated over a spirit lamp. In 3 minutes you observe they are converted into water. Within what time would you expect to see the water (1) boiled; (2) all boiled away?—M.U., 1901.

Q. 527.—A piece o ice is heated in an open vessel until the whole of the contents of the vessel have disappeared. State precisely, in the order in which they occur, all the changes produced by the application of heat to the ice.—M.U., 1898.

Q. 528.—Describe three experiments illustrating conductivity of heat in such a way as to bring out the principal points of this property of matter.—L.U., 1899 June.

Q. 529.—How would you propose to prove by experiments that to boil away a gallon of wat r requires about $5\frac{1}{3}$ times as much heat as is needed to raise it from the freezing point to the boiling point?—L.U., 1899 June.

Q. 530.—A silver tea-pot weighs 300 grammes. One gramme of silver requires as much heat to warm it as would be required by ·056 gramme of water to warm it equally. The tea-pot contains 20 grammes of tea leaves and each gramme of tea leaves requires as much heat to warm it as would suffice to warm equally 0·5 gramme of water. If 600 grammes of boiling water be passed into the tea-pot, calculate the highest temperature of the tea, assuming that tea-pot and leaves were originally at 15° C.—L.U., 1900 Jan.

Q. 531. How would you show that more heat is required to raise a weight of water through 1° C. than to raise a weight of lead through 1° C.?—L.U., 1903.

Q. 532.—Give an example of a freezing mixture and explain what the freezing is due to.—M.U., 1899.

Q. 533.—What is meant by the latent heat of water? Calculate what would be the result of putting 3 lbs. of ice at 0° C. into 5 lbs. of water at 30° C., supposing no heat is obtained from surrounding bodies.—M.U., 1897.

Q. 534.—What are the trade winds? How are they caused?—M.U., 1897.

Q. 535.—Describe an experiment in which water is forced to boil so fast that it freezes.—L.U., 1901.

Q. 536.—On some days a steam engine leaves a long white cloud behind it, and on one other days only a short one. Explain this by

UNANSWERED QUESTIONS—*continued.*

describing in each case why the cloud forms, and why it disappears.—L.U., 1900 Jan.

Q. 537.—"We have at the equator a system of upward currents which carry off the hot air to the poles in the upper regions of the air, and we have also currents blowing along the surface of the earth. . . . . ." What are these surface currents called? Account for their name and explain the direction in which they blow.

Q. 538.—State and explain the direction of the winds blowing in the upper regions of the air mentioned in the above question.

Q. 539.—By what experiments would you show that different amounts of heat are absorbed when equal masses of different substances are heated through the same range of temperature?—Lon Mat., 1901. Jan.

Q. 540.—Explain the term *latent heat* and describe any manner in which the latent heat of water may be determined.—B.U., 1899.

Q. 541.—What becomes of the heat spent in just melting ice into water, and in turning water at 100° C. into steam? What is the heat so spent called and why?—M.U., 1901.

Q. 542.—Crystallised calcium chloridea nd ice mixed together in fine powder liquefy and become very cold. Why is this?—L.U., 1903 June.

Q. 543.—Three kgrms. of water at 80° C. are mixed with 1 kgrm. of ice at 0° C. What will be the temperature, when the ice is melted and how many kgrms. of vapour at 100° C. will be required to produce the same effect? Latent Heat of water 80: of steam, 536.—B.U., 1899.

Q. 544.—500 grammes of a metal at 99·5° C. are placed in 450 grms. of water at 15° C. The water rises by 23·5° C. Calculate the Sp. Ht. of the metal.—Pun. Ent., 1903.

Q. 545.—Define the *latent heat* of water. How would you determine the latent heat of water?—Pun. Ent., 1904.

Q. 546.—How is mercurial thermometer made and graduated? Why is mercury used in preference to other liquids? What advantages has alcohol over mercury?—Pun. Ent., 1904.

Q. 547.—Describe the changes when 1 lb. of ice at 0° C. is driven off as steam at 100° C.—Pun. Ent., 1901.

Q. 548.—Half a pound of ice at 0° C. is thrown into 5·76 lbs. of water at 85° C. Find the temperature of water when all the ice has melted away.—Pun. Ent., 1901.

Q. 549. If a pound of boiling water be mixed with $4\frac{1}{2}$ lbs. of mercury at 10° C., what will be the temperature of the mixture?—Pun. Ent., 1902.

Q. 550.—Mention any experiments or any personal observation of your own which lead you to believe that heat is a form of energy.—Pun. Ent., 1900.

Q. 551.—Two similar brass vessels, containing 2 lbs. of ice and 1 lb. of boiling water, respectively, are placed over the same fire. Compare the time it will take for the ice to melt with that taken by the water to boil completely away into steam.—M.U., 1904.

Q. 552. Describe three different methods by which a tumbler of hot water may be cooled.

Q. 553.—Two pieces of ice weighing one pound each at 0° C. are thrown separately into equal weights (2 lbs. of each) of water and mercury, both at the boiling point of water. Which piece of ice will turn water sooner, and why?

Q. 554.—What is meant by saying that the specific heat of a body is ·03? (1) Into an iron vessel weighing 4 lbs. and containing 3 lbs. of water at 30° C. 5 lbs. of mercury at 455° F. are poured. (2) Two pounds of steam at 100° C. are passed into an iron vessel weighing 5 lbs. and containing a mixture of 2 lbs. of ice and 16 lbs. of water at 0° C. Calculate the result in the above two cases, taking the specific heat of iron to be ·11, the specific heat of mercury ·03, the latent heat of water 79, and that of steam 537.

Q. 555.—Explain why strong iron pipes burst in winter in cold countries.

Q. 556. Calculate the amount of heat required to melt 15 lbs. of lead at 115° C. (Lead, Sp. Ht. ·031; latent heat of fusion 5·07; melting point 334° C.)

Q. 557.—Give examples to show that (1) heat causes chemical changes. (2) Some chemical changes produce heat, while others absorb heat. (3) Sometimes simple contact of substances causes chemical union. (4) In some cases heat is absolutely necessary to start chemical union.

Q. 558.—A paper set on fire burns away soon. But a paper cup containing water does not burn away when heated on a flame, although the water inside becoms very hot. Explain this.

Q. 559.—Three separate mixtures are made, *viz.*, (1) water and snow, (2) snow and salt, (3) water and salt. If all the materials were at 0° C. before being mixed, which mixture will be at the highest temperature and which at the lowest? Why?

UNANSWERED QUESTIONS—*continued.*

Q. 560.—One kilogram of water at 100° C. is allowed to cool down to 29° C. If the heat given out by the water had been employed to heat 30 kilograms of mercury at 0° C., to what temperature would that be raised? Sp. Ht. of mercury ·03.—B.U., 1901.

Q. 561.—Taking the heat absorbed by the melting of a pound of ice as 80, and that absorbed by the evaporation of a pound of water at 100° C. as 540, find the result of blowing a pound of steam at 100° C. into a mixture of 10 lbs. of water and 10 lbs. of ice at 0° C.—L.U., 1903.

Q. 562.—One kgrm. of ice at 0° C. is placed in five kgrms. of water at 0° C. and one kgrm. of steam at 100° C. is passed into it. What will be the final temperature and what will be the final state of the ice, water and steam?—B.U., 1900.

SECTION V.

LIGHT AND ELECTRICITY.

Q. 563.—State the two laws in accordance with which a ray of light is reflected by a smooth surface, and describe experiments by which you would demonstrate the truth of each of these laws. Lon. Mat., Jan. 1900; Pun. Ent., 1901.

Ans.—(i) The angle of incidence is equal to the angle of reflection.

(ii) The incident ray and the reflected ray are both in the same plane with the normal *at the place* where the ray strikes the mirror.

(1) These two laws may be verified with the help of an apparatus in which there are two tubes which are movable on the circumference of a graduated circle. These two tubes are so placed that they always remain directed towards the centre. In the centre is fixed a small polished plate. The rays from any source of light, such as the flame of a candle, are made to pass through one of the tubes; these rays after passing through the tube strike the polished plate in the centre and are reflected. The other tube is now moved along the circumference till the observer sees the reflected light through it. When this position is found and the distances of the tubes from the highest point of the circle are measured, the graduations

will be found to be exactly equal on either side of it, in other words, one arc is equal to the other. Since equal arcs are subtended by equal angles at the centre, the angles subtending the two arcs at the centre are equal, *i.e.*, the angle of incidence is equal to the angle of reflection; and since the incident ray, the reflected ray and the normal are in the plane of the circle, they are all in one plane.

(2) "Fasten a little whitened wooden stick with wax perpendicularly at the centre of a plane looking glass. Cast upon the mirror, at the foot of the rod, a beam of parallel rays from the lantern." It will be noticed that the angles made by the incident beam of light and the reflected beam with the rod are equal and that they are in the same plane.

Q. 564.—What is light? Explain clearly why, if light were matter, "we should be knocked to pieces by a ray of light" from the sun.

Ans.—Light is the physical agent which, acting on a certain portion of our eyes called the retina, enables us to see things. Light is the result of a kind of wave-motion; it consists of ether-waves which are set up in ether by the particles of a luminous body. If light were matter emitted by luminous bodies, the minute particles of matter composing the light of the sun must be *darted* from that great distance—else, there is no reason why these particles should leave the sun. Hence, these particles of light must reach us with a very great force, for being darted with an *immense velocity*, they must possess a very great momentum, minute though they be. Therefore, we must be receiving severe shocks owing to the great momentum of the particles whenever we go out in the sun.

Q. 565.—*How has it been proved* (*1*) *that light takes time to travel*, (*2*) *that light travels much faster than sound?*—M.U., 1895.

Ans.—(1) Jupiter is a planet that revolves round the sun just like the earth. There are five moons or satellites revolving round Jupiter. The nearest satellite takes 42 hrs. 28 36 to make a complete revolution round Jupiter. Once in its revolution, it passes into Jupiter's shadow. Therefore this satellite *enters* Jupiter's shadow regularly once in 42 hrs. 28′ 36″; in other words, it is eclipsed and goes out of sight once in every 42 hrs. 28′ 36″. If, therefore, we note down the time when any such eclipse of the satellite takes place, we can calculate and tell exactly the time when the next, the 5th or the 6th or the 25th or any other subsequent eclipse, would take place.

When the earth was at K, that part of her *orbit* which is nearest to Jupiter (fig. 56). the time was noted when an above mentioned eclipse took

Fig. 56.

place and calculations were made when the next, the 3rd and the 4th and the subsequent eclipses, ought to take place. It was found that as the earth moved in her orbit away from K, *i.e.*, farther from Jupiter, there was a difference between the time *when the eclipses actually took place* and *when they ought to have taken place according to the calculation*. The greatest difference in time thus observed was, when the earth was on the other side of her orbit *farthest* from Jupiter, *i.e.*, at L. Then, the eclipse of the satellite was seen to have taken place 16 minutes and 26 seconds after the calculated time ; if, for example, the eclipse ought to have begun, according to the calculation *made before*, at 4 o'clock on a certain day, it began not at 4 o'clock, but 16 minutes and 26 seconds afterwards. This difference of time must have been the time taken by the light from Jupiter's satellite to cross the earth's orbit, *i.e.*, KL. Knowing the diameter of the earth's orbit and the time taken by light to go across it (16 26). Romer calculated that the velocity of light was 186.000 miles per second

(2) A gun was fired at a distance from an observer. The flash of the gun was seen first and the sound of it was heard later on, thus showing clearly that light travels much faster than sound.

Q. 566.—*Explain the terms*: Ray, pencil, diverging pencil, parallel pencil, mirror, image, and converging pencil.

Ans.—'*Ray*' is the name given to the line of direction in which light travels. '*Pencil*' of light is the name given to a collection of light rays. '*Diverging*' pencil is a collection of light rays that go on separating from one another as they proceed; as, the light proceeding from a candle flame. '*Parallel*' pencil is a collection of rays that go on parallel as they proceed; as, the light from a lamp placed in the focus of a double convex lens *after passing through the lens.*

'*Mirror*' is the name given to any polished surface which can form the image of the object presented to it.

'*Image*' is the name given to the appearance of an object in a mirror

'*Converging pencil*' is the name given to a collection of light rays which meet or tend to meet at a point: as, the light of the sun, *after passing through a double convex lens.*

Q. 567.—(*a*) Into how many classes may bodies be divided according to their power of allowing light to pass through them? (*b*) Explain them and state to which of them a glass mirror belongs. (*c*) Arrange the following substances in those classes: air, water, mercury, glass mirror, polished marble, tissue paper, red glass, ground glass, paper.

Ans.—(*a*) Three classes: Transparent, translucent, and opaque bodies. (*b*) Transparent bodies are those that allow light to pass through them: as, a pane of glass. Translucent bodies are those that allow light to pass through them imperfectly: as, an oiled paper. Opaque bodies are those that do not allow light to pass through them: as, a block of wood.

[*N.B.*—Hence, (1) we can see things through a transparent body distinctly; (2) things appear indistinctly through a translucent body; (3) we cannot see things through opaque bodies.]

Glass mirror is an opaque body.

(*c*) *Transparent bodies*: Air, water, glass, red glass. *Translucent bodies*: Tissue paper, ground glass. *Opaque bodies*: Mercury, polished marble, paper, glass mirror.

Q. 568.—Give three proofs to show that light travels in straight lines.

Ans.—(1) The simplest way is to place a finger in the right line joining the eye and an object at a distance; the object will not be seen. Since *we do not see anything unless the rays of light from that thing fall on our eye*, and since the interposition of the finger in the straight line joining the eyes and the object prevents our seeing the object, we infer that the rays of light travel in straight lines. (2) Place two screens each pierced with a hole at a little distance from each other in such

Fig. 57.

a way that the holes may be in a line with the flame of a candle. An eye to can see the flame from behind the screens if placed in the prolongation of the right line joining the holes, wherever it may be. A slight *lateral* displacement of any of these—the candle, the screens or the eye—puts the flame out of sight. (3) The same fact is also illustrated by the images produced by minute apertures. If behind a small hole made in the shutter of a dark room, a white screen is placed at the proper distance, then inverted pictures of the trees, etc., lying outside will be formed on it. (See fig. 57.) If light did not travel in straight lines, we could not account for the formation of these *inverted images*.

Q. 569.—When we look at some stars we see them as they were two or three years before, and not as they are at the moment at which we are looking. Explain this.—M.U., 1888.

Ans.—Light travels with the enormous velocity of 186.000 miles per second. There are stars, the light of which takes two or three years to reach us. We see a thing only when light from that thing falls on our eyes. Now the light which reaches us from those stars is what has left them two or three years ago. Hence, we see those stars as they were two or three years back and not as they are now.

Q. 570.—A ray of light strikes the surface of a glass plate and is reflected. Describe clearly, and give a diagram to show the course of the ray after reflection.—M.U., 1896.

Ans.—If the ray strikes the glass plate *perpendicularly* it will be reflected back in the same direction. If the ray of light strikes the mirror *obliquely* it will proceed, after reflection, in such a direction that this direction and the direction of incidence make equal angles with the normal at the point of incidence.

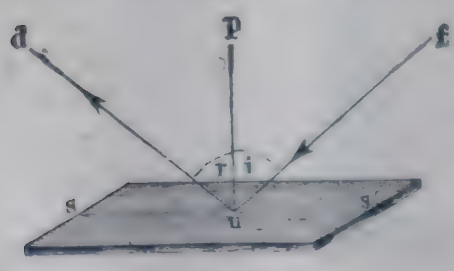

Fig. 58.

In fig. 58, *fn* is the incident ray and *nd* is the reflected ray. *np* is the normal at *n*. *i* is the angle of incidence and *r* is the angle of reflection. Therefore a ray striking the glass plate in the direction of *fn* proceeds after reflection in the direction of *nd*.

Q. 571.—Give the geometrical reason why the image of a middle flame seems to be as far behind a flat mirror as it actually is in front of it—M.U., 1884; 1894.

Ans.—In the case of plane mirrors the distance between the image of an object and the mirror is equal to the distance between the mirror and the object before it. The truth of this can be demonstrated geometrically. Let A (fig. 59) be any bright object before the mirror MN. Rays of light proceed from the object in all directions, and such of them as strike the mirror are reflected and *the image of the object will be seen in the direction of the reflected rays, i.e.*, at the place where the prolongations of the reflected rays meet.

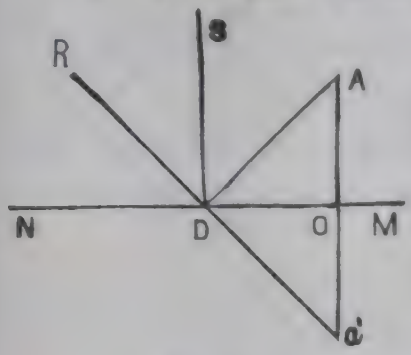

Fig. 59.

Drop AO perpendicular and take AD another incident ray. The ray that falls in the direction of AO is reflected upon itself, and so the image of A would be seen in the mirror somewhere in the prolongation of AO. AD is another incident ray. Let us find out in what direction it proceeds after reflection. At the point D draw a normal DS, and at the point D in the straight line SD make an angle SDR equal to the angle SDA. Now DR is the direction of the reflected ray, and image of A will be seen in the prolongation of RD also. Produce RD and AO to meet at the point a'. The image will be seen at a' and we have to prove that AO, the distance between the object and the mirror, is equal to $a'O$, the distance between the image and the mirror.

In the two triangles AOD and a'OD the angle AOD is equal to the angle a'OD, both being right angles; and the angle ADO is equal to the angle a' DO; because the angles SDN and SDM are equal, being right angles, of which the parts SDR and SDA are equal being the angles of incidence and reflection; then the remaining angles ADO and RDN are equal. But RDN is equal to a'DO (Euclid 1 - 15). Therefore, the angle ADO is equal to angle a' DO.

Now in the two triangles AOD and a'OD, the two angles AOD and ADO are equal to the two angles a'OD and a'DO respectively, and the side OD is common to the two triangles AOD and a'OD; therefore the side AO=a'O (Euclid 1—26.)

Q. 572.—If a bright point moves away from the mirror with a velocity of 5 feet per second, at what rate do the point and its image separate?—M.U., 1891.

Ans.—In a plane mirror the image appears to be as far from the mirror as the object is in front of it. Hence, if the object be 5 feet from the mirror, its image will appear to be also 5 feet from the mirror, *i.e.*, the object and the image are separated by 10 feet. Therefore, the velocity of their separation is 10 feet per second.

Q. 573.—State the difference between a virtual image and real image. Is your image in a looking glass a virtual one or a real one? Give reasons.

Ans.—A *virtual image* is that which cannot be received on a screen. *Real images* are those that can be received on a screen. Images formed by a looking glass are virtual ones, for they cannot be received on a screen.

Q. 574.—The distance of an object from the mirror and the distance of its image from the mirror are equal. Is this a law of reflection?

Ans.—No. It is a *fact* which is true only in the case of plane mirrors. This fact can be demonstrated geometrically with the help of the known laws of reflection.

Q. 575.—What is a concave mirror? Describe the different kinds of images which it can produce; state the condition in which it will form no image.

Ans.—A concave mirror is a curved mirror in which the reflection takes place from the hollow part. In some cases it forms real images, and in some cases virtual ones according to the position of the object.

(1) Present the mirror to a distant object—say a tree. A smaller and inverted image of the tree will be formed, and this can be received on a screen held properly before the mirror. The position of the image formed will be somewhere between the centre of curvature of the mirror and its focus. The farther the object is, the nearer will the image be to the focus of the mirror. If the object be as far as the sun itself, the image will be almost in the focus itself. The nearer the object is to the mirror, the nearer will be its image to the centre of the curvature. (The centre

of curvature is the centre of the sphere of which the mirror is a part. It is marked C in the accompanying figure.)

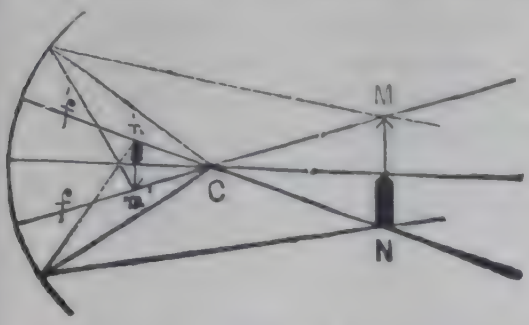

Fig. 60.

Suppose MN is the distant object (fig 60). Rays of light from the various points of MN strike the mirror and are reflected. These reflected rays meet and form an image *mn* as represented in the figure. The image *mn* will be nearer to *ff* or C according as the object MN is far away from or nea. to the mirror.

(2) Suppose the object is between the focus and the centre of curvature as MN in the fig. 61. Then an nverted bigger and real image of it will be formed somewhere beyond the centre of curvature. If thr object be nearly on the focus, its image will be very far—as far as the sun itself. If, however, the object be between F and C as MN in the fig. 61. then its image will be somewhere beyond C as *mn*.

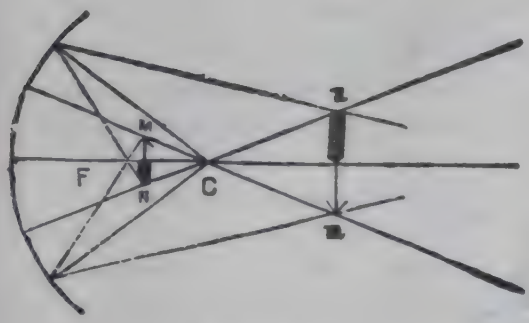

Fig. 61.

(3) Take the concave mirror very near to your face and look at your image therein ; you will find an erect and bigger image of your face. This image is not real, because it cannot be received on a screen. Therefore, if an object be placed between a concave mirror and its focus, an erect, bigger and virtual image of the object will be seen in the

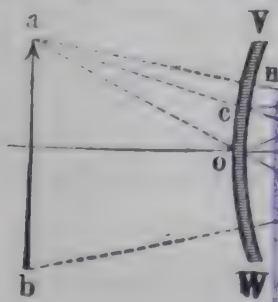

Fig. 62.

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mirror. Fig. 62 illustrates how a concave mirror forms a bigger and virtual image of the object placed between the mirror and focus.

(4) Place in the focus of a concave mirror a lighted candle. No image of the flame would make its appearance anywhere; the light that is reflected appears bright and brilliant. The reason is this. The rays of light from that candle after striking the mirror proceed in parallel pencils, so that no image is formed and the light that is reflected appears bright and brilliant. Owing to this fact concave mirrors are largely made use of as reflectors in many lamps.

Q. 576—Describe the image formed by a convex mirror.

Ans.—When an object is presented to a convex mirror an erect and virtual image of it is formed in all cases, whether the object is farther from, or nearer to, the mirror. The size of the image, however, will be different—smaller when the object is farther, and bigger when the object is nearer to the mirror. But in no case will the image formed in a convex mirror be bigger than the object itself. An inspection of the fig. 63 will enable you to see how an object forms its image in a convex mirror. MN is the object and *mn* is its image formed in the mirror.

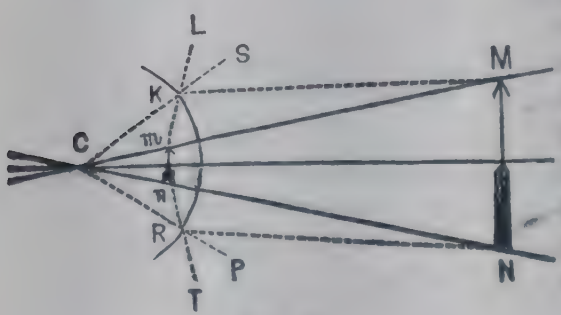

Fig. 63.

Q. 577.—In what respects does the image formed by a convex mirror differ (1) from the object, (2) from the image formed by a plane mirror?—M.U., 1900.

Ans.—(1) The image is smaller than the object, virtual and erect.

(2) In a plane mirror the image is as big as the object. It is virtual and reversed (the right of the object appearing as the left of the image, and *vice versa*). Moreover, the distance of the object from the mirror does not affect the size of the image. In a convex mirror, the farther the object is, the smaller the image will be.

Q. 578.—How would you determine the focus of a concave mirror? Why has a concave mirror been called a burning mirror?

Ans.—Present a concave mirror to the sun. The rays of the sun that fall on the mirror, after undergoing reflection, will meet (fig. 64) at a certain point in front of the mirror. This point is known as the focus of the mirror and is so hot as to set fire to a combustible substance, such as a piece of paper, or cotton, when placed there. To determine the focus of a concave mirror, therefore, present the mirror to the sun and find out *by trial* the place where a combustible substance takes fire. The distance between the focus and the mirror is known as the focal length of the mirror. The focal length of a concave mirror is very nearly half of the radius of the sphere of which the concave mirror is a part. Owing to the fact that by means of a concave mirror, a combustible substance can be set fire to, it has been called a ***burning mirror***.

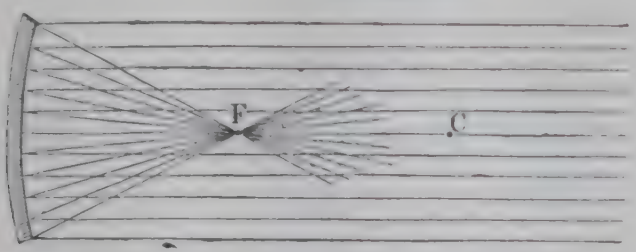

Fig. 64.

Q. 579.—(*a*) What is meant by Refraction? (*b*) Explain by the help of a diagram how a small object lying at the bottom of a vessel may be visible when the vessel is full of water, but invisible when the water is removed.—M.U., 1885; 1889.

Ans.—(*a*) The deviation from its course, which light undergoes when it passes from one medium to another of a different density, is called '**Refraction.**'

(1) A coin is placed at the bottom of an empty basin and a person stands at such a distance from it that the side of the basin *just hides the* coin from the person's sight. If now water is carefully poured into the basin the man will see the coin distinctly, and if the water is removed, the coin again disappears from his sight. This reappearing of the coin when water is poured into the basin is due to the bending which the rays from the coin undergo. Before the water is poured, the rays from the coin proceed in the direction of CAS (fig. 65), and do not strike the person's eye. When water is poured the same rays undergo refraction and proceed as

CAR. As the rays pass from water (a denser medium) to air (a raerr medium) they go away from the normal AN and strike the man's eyes who is thus enabled to see the coin.

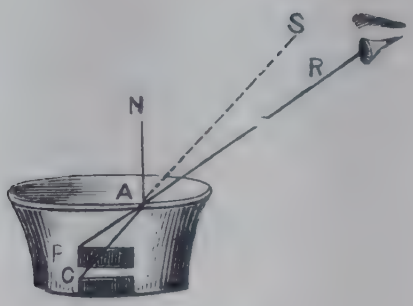

Fig. 65.

Q. 580.—State the laws of refraction and mention any two instances of its effect.

Ans.—When light passes from a rarer medium to a denser medium (as from air to water) the refracted ray approaches the normal; and when it passes from a denser medium to a rarer medium (as from water to air or from glass to air), the refracted ray goes away from the normal. In any case a ray that falls perpendicularly undergoes no deviation whatever, but passes right through.

(1) When a stick is placed obliquely in water, the part in the water appears to make an angle with the part outside, *i.e.*, the stick appears to be bent at that part (see fig. 67).

(2) The sun and the stars appear to us, when they are not above the horizon—even when they are a little below it—and this is owing to the refraction which their rays undergo when they pass through the atmosphere. The atmosphere is denser nearer the earth. So, the rays have to pass from a rarer medium (parts of the atmosphere farther from the earth) to a denser medium, and hence bend towards the normal. Thus, the sun and the stars are seen even when they are a little below the horizon, for the rays from them strike a man's eyes on account of the refraction.

Q. 581.—What happens, when light passes through a glass plate with parallel faces?

Ans.—When light passes through such a medium it undergoes refraction twice before it emerges from the medium—first, when it enters the medium and second, when it leaves it. The effect of these two refractions is to make the incident ray parallel to the emergent ray. The ray AB that falls on the glass plate KL (fig. 66) passes from a rarer medium to a denser one and so it approaches the normal and passes in that direction BC through the glass plate. The ray after passing through the glass plate emerges into the air, and as it passes from a denser medium to a rarer medium it goes away from the normal CM, and proceeds as CD. It goes away from the normal to the same extent to which it approached the normal when it entered the glass plate. The effect of these two refractions, therefore, is to make the incident ray AB and the emergent ray CD parallel to each other.

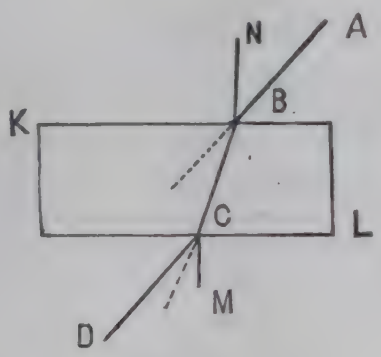

Fig. 66.

Q. 582.—A beam of light, on passing obliquely from air into water, is bent away from the surface of water, but if the end of a striaght stick be plunged obliquely into water, the part immersed appears to be bent towards the surface. Show that both effects are illustrations of the same law of refraction.—M.U., 1898.

Ans.—When light passes from a rarer to a denser medium it approaches the normal and so the beam is bent away from the surface of water; but when light passes from a denser medium the rays go away from the normal. The rays proceeding from the part of the stick in the water go away from the normal. The stick in the water appears in the direction of these rays. The part of the stick in the water appears towards the surface of the water, because, as can be seen from fig. 67, those rays when produced approach the surface of the water.

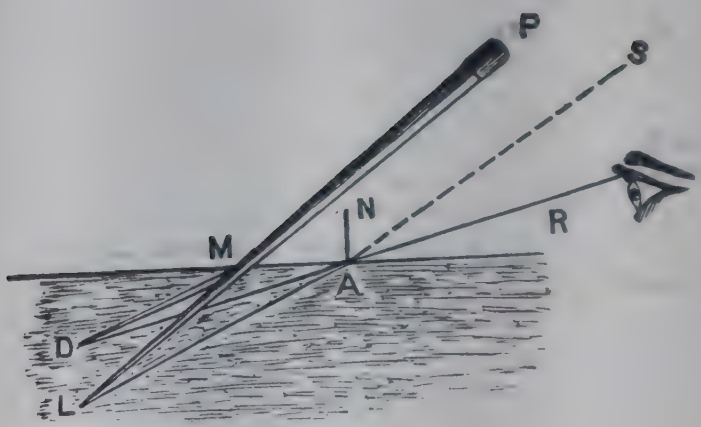

Fig. 67.

Q. 583.— What is a lens? Light from a very distant object falls on a lens; draw, on a large scale, a diagram showing the path of the rays of light.—M.U., 1886.

Ans.—A lens is a transparent medium which, from the curvature of its surfaces, has the power of making the rays that fall upon it converge or diverge. Fig. 68 shows how the rays from the distant object MN after passing through the lens, form a small and inverted image *mn* the other side.

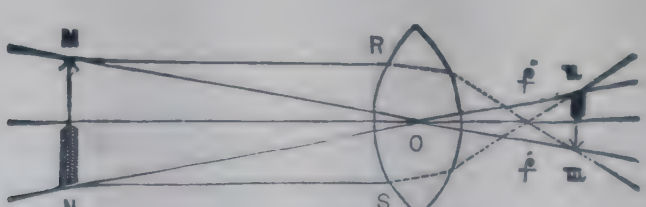

Fig. 68.

Q. 584.—If a flat thick piece of glass is laid on a printed page of a book and we look at the page in a slanting direction, we see the letters as if lifted up. Explain this clearly.—M.U., 1887

Ans.—This is due to refraction. The rays proceeding from the letter after passing through the glass go away from the normal. When they strike the eyes of the man, he sees them in their direction at the place where the line at right angles from the letters meets them. This place is higher than the position of the letters. Hence, the letters appear lifted up

Q. 585.—Describe an experiment proving that white light is compound.—M.U., 1902 R.

Ans.—Through a glass prism pass a pencil of the light of the sun as shown in the figure. Then as soon as it enters the prism, it is separated into its component lights, *because different coloured lights bend in different degrees when they pass from one medium to another.* When these leave the prism, the separation will be increased for the same reason (fig. 69). On a screen held at V R a band of different colours will be seen.

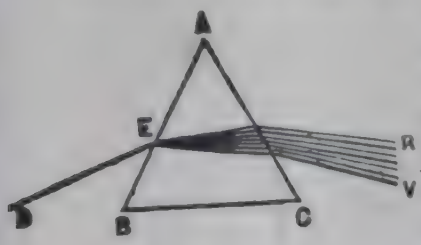

Fig. 69.

Q. 586.—Explain, in general, the formation of a rainbow.

Ans.—A rainbow is always formed on account of the dispersion which the sun's light undergoes when it passes through the drops of water in the falling rain or hanging clouds [fig. 70]. A rainbow, therefore, is seen only when the sky is rainy or cloudy, and only opposite to the sun. The

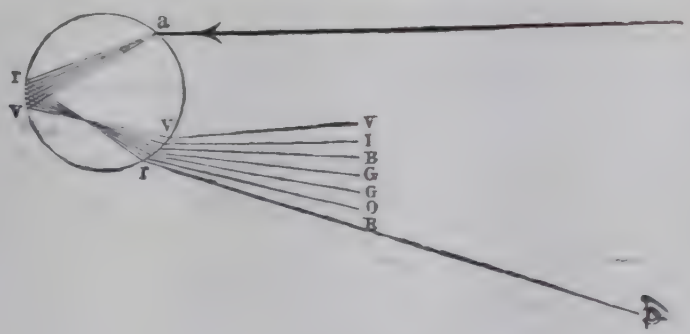

Fig. 70.

circle in the figure represents a drop. The sun light enters at *a*. It undergoes dispersion as shown in the figure, and different coloured rays strike the observer's eye.

Q. 587.—I have on a table a broad flat vessel containing mercury to a depth of one inch, and water to a depth of six inches over the mercury. By means of a very small mirror a beam of sunlight is made to fall obliquely into the vessel so as to be reflected by the mercury at the bottom and thereafter to fall on

the wall. Show by a large figure the path of the light from the small mirror to the wall.—M.U., 1904.

Ans.—

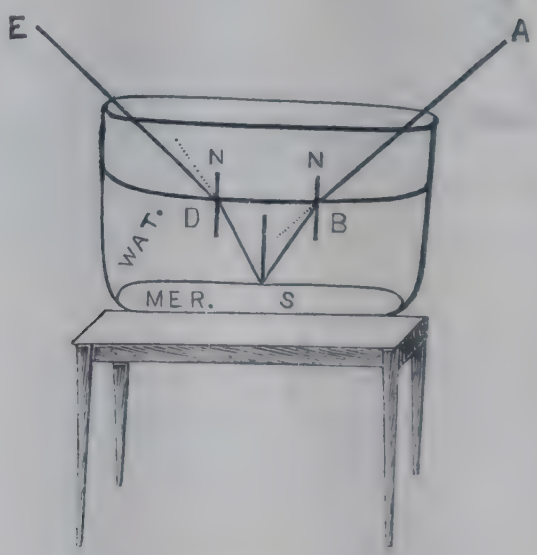

Fig. 71.

[**Mercury is bright, but not transparent**: *it is opaque* Hence, light does not pass through that. Therefore, the rays of light must not be shown in the figure as passing through mercury. They must be shown as being reflected from the surface of it.]

Q. 583.—Why is the beam of sun's light not only bent but broken up into a coloured band by the prism? Name the colours in the order in which they will be seen on a screen.—M.U., 1884.

Ans. -(1) Rays of light when passing from one medium to another of a different density bend; (2) different kinds of rays have different degrees of bending.

The light of the sun is composed of different kinds of light. Hence, when the sun's light passes through a prism it is broken up into its elementary parts.

Violet, indigo, blue, green, yellow, orange and red are the rays in the proper order on the screen. *Violet* is the most refrangible and *red*, the least. Violet appears towards the base and the red towards the edge of the prism. (Fig. 69.)

Q. 589.—(*a*) What is a prism? (*b*) What are the facts regarding light that are exhibited when a sunbeam is made to pass through a glass prism and then to fall upon a white screen? —M.U., 1895.

Ans. (*a*) A prism is *any* transparent medium between two plane faces which are inclined to each other. Thus, we may have a prism of glass or of ice.

(*b*) (1) That the light of the sun is a compound light.

(2) That the light of the sun is composed of seven different colours—violet, indigo, blue, green, yellow, orange and red.

(3) Violet is the most refrangible and red is the least refrangible of those rays.

Q. 590.—Explain, with the help of a figure, why things appear displaced when looked at through a prism.

Ans.—If a ray of light MN from any object M (fig. 72) falls upon the side AB of the glass prism ABC then, as it has to pass from a rarer medium (air) into a denser medium, it approaches the normal and passes as NR and not in the former direction which would have been its course if the prism had not been in its way. Again when NR leaves the prism it has to pass from a denser medium (glass) into a rarer medium (air) and so, it goes away from the normal and emerges as RE: (and not in the former direction which would have been its path, if the rays should still continue their course in the prism). The emergent ray thus bends towards the base. Therefore, when light falls on one of the sides of a prism it undergoes refraction twice—first, when it enters the prism and, secondly, when it leaves it: the effect of these two refractions is to make the emergent ray bend towards the base of the prism. A substance at M when looked at through the prism appears in the direction of ER, right above M *i.e.*, at the point S, because the rays are bent and come out in the direction of RE; and things are seen in the direction of the rays which strike a man's eyes. Thus, things when seen through a prism appear to be displaced towards its edge.

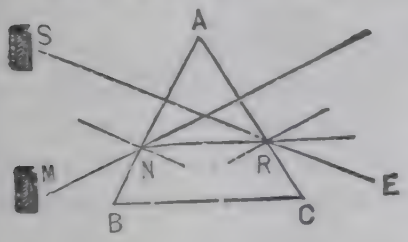

Fig 72.

Q. 591.—A hole in the shutter of a room is looked at through a prism with its edge horizontal. Describe what will be seen. M.U., 1892.

Ans. (i) The hole will be seen displaced towards the edge, *i.e.*, if the edge be held upwards, the hole appears raised, and if the base be held downwards the hole appears lowered.

(ii) The hole will be seen to be fringed with different colours—red, orange, yellow, green, blue, indigo, violet; in other words holes of these different colours will be seen one above the other in order, so that a band of different coloured holes will be seen.

Q. 592.—A beam of sunlight passes through a slit, and then through a prism of red glass, and falls on a screen. If this prism be replaced by an exactly similar prism of blue glass in the same position, describe and account for any change in the appearance or the position of the light patch on the screen.—M.U., 1896.

Ans.—In the first case a red image of the slit is formed on the screen because all the rays of the sun are absorbed by the red glass prism except the red rays.

In the second case, the blue glass absorbs all the rays of the sun except the blue. Hence, the blue rays of the sun-light pass through the blue prism and form a blue image of the slit on the screen. So, in this case a blue image of the slit will be seen on the screen. As blue rays bend more than the red rays, the blue image of the slit appears lower down the screen than the red image.

Q. 593.—Suppose some blue, orange, indigo and yellow light fell from the same direction on a horizontal prism, would they emerge together? If not, in what order?—Pun. Ent., 1901.

Ans.—No. They would not emerge together. Different lights have different degrees of refrangibility. Indigo rays would pass approaching the base most and then blue, yellow, and orange rays would come in order. Orange rays, being the least refrangible of those given, would pass nearest to the edge of the prism.

Q. 594.—In the shutter of a dark room there is a narrow slit which is covered, the lower half with red and the upper with blue glass: a prism is placed near the slit with its edge parallel to it, and the refracted image is caught on a screen. Describe and explain the appearance of this image.—M.U., 1890.

Ans.—Through the red glass only the red rays pass, and through the blue glass only the blue rays pass. Hence, on the screen two images appear—one blue and the other red. The blue rays being more refrangible than the red, the blue image appears on the screen more towards the base of the prism, and the red image more towards the edge of the prism.

Q. 595.—Describe and explain by means of a figure how a lens forms an image of a distant object.

Ans.—Present the lens to a distant object—a house or a tree. If, on the other side of the lens you hold a screen at the proper place, an inverted and smaller image of the object makes its appearance on the screen. A double convex lens, therefore, can be used to produce *real* images of distant objects. The size of the image depends upon the distance of the object from the lens. If the object be as far as the sun itself, its image will be on the focus and extremely small. If the object is not so very far, then its image will be a little farther from the focus on the other side of the lens as in the fig. 68. If the object is nearer to the focus on the one side, its image will be farther from the focus on the other side. In the figure 68, MN is an object at a distance. You see that it forms a smaller and inverted image as *mn* on the other side beyond the focus. The path of the rays is as follows:—Rays from M after passing through the lens meet at *m*. (In *all* the lenses there is a point such that the rays passing through that point undergo no refraction. That point is called the optical centre and is marked O in fig. 68. MO, therefore, undergoes no refraction while the ray MR undergoes refraction and meets MO produced at *m* beyond the focus. The rays proceeding from M do not meet at the focus, because the object is not at an infinitely great distance. The image of M, therefore, is formed at *m*; for the same reason the image of N is formed at *n*. The images of the points between M and N are formed between *m* and *n*, so that the object MN forms its image as *mn*.

Q. 596.—How can you use lenses for examining (1) near objects, (2) distant objects?—M.U., 1888.

Ans. (1) The object to be examined is placed between the lens and its focus as MN in the fig. 73. It is then looked at from the other side of the lens. The rays from the object proceed through the lens and strike the observer's eye as shown in the figure

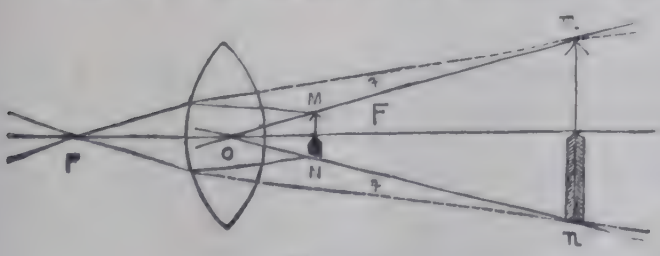

Fig. 73.

and the observer sees an enlarged image *mn* of the object which is virtual and erect. For this reason, lenses are called magnifying glasses.

(2) Present a double convex lens to the distant object. A small image of the object will be formed on the other side of it. Place another double convex lens in such a way that the image may be between the focus of this lens and its focus. The image formed by the first lens will be magnified by the second lens. Arrangement of lenses in this way for the purpose of examining distant objects is called a telescope. Fig. 74 shows the path of rays from the object AB to the observer's eye, in a telescope.

Fig. 74.

Q. 597.—Explain the terms—spectrum, dispersion, deviation and focus.

Ans.—*Spectrum* is the name given to the bright band of light obtained after passing any light through a prism.

Dispersion is the process of separation into its elementary parts, which compound light undergoes when it is passed through a prism.

Deviation is the displacement from its previous course which light suffers when it passes from one medium to another of different density.

Focus is the name given to the point where the light rays meet after reflection from the surface of a curved mirror ; or where the light rays meet after refraction through a lens.

Q. 598.—How would you find the focus of a concave mirror and of a lens ?—M.U., 1893 ; Pun. Ent., 1900.

Concave mirror. Hold a concave mirror in such a way that the rays of the sun may fall on it. These rays will undergo reflection and after reflection will meet at a point (fig. 64) ; this point is hot enough to set fire to paper or cloth. Find out this point by trial and that is the focus.

Lens.—Hold a double convex lens in such a way that the rays of light from the sun may fall on one of its faces. The rays after passing through the lens meet at a point on the other side of the lens. (Fig. 75.) This point is called the focus of the lens and is so hot as to set fire to a combustible substance, such as a piece of paper or cloth placed there. This point can be easily found out by trial.

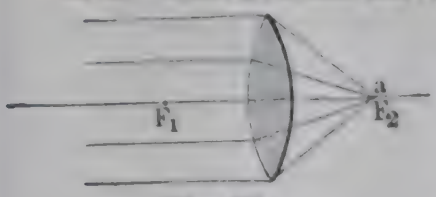

Fig. 75.

Q. 599.—Describe exactly what happens to the direction and quality of the light when a narrow beam of parallel white light falls on one face of a three-cornered prism, held in such a way that the light emerges through an adjacent face of the prism. What would you see, if this light after passing through the prism is received on a sheet of white cardboard? What difference would it make, if this beam of light before entering the prism is passed through a sheet of red glass ?—L.U., 1899 Jan.

Ans.—The light after passing through the prism bends towards the base of it. The light also undergoes separation into its elementary parts, and so, different coloured rays emerge from the other side of the prism.

On the sheet of cardboard held in position a bright band of seven different colours will be seen. Red light appears towards the edge of the prism, and violet appears towards the base of it.

Between these two appear indigo, blue, green, yellow and orange coloured rays in order, indigo being above violet, blue above indigo, and so on.

In the case given, where the light is passed through a red sheet of glass before passing through the prism, only red rays fall on the prism. Being an elementary light it undergoes no separation. On the screen only a red patch of light will be seen.

Q. 600. Explain the phenomena of *colour* in bodies.

Ans.—"Natural bodies possess the power of extinguishing, or as it is called *absorbing*, the light that enters them. This power of absorption is *selective*, and hence, for the most part, arise the phenomena of *colour*. When the light which enters a body is *wholly* absorbed the body is black. A body which absorbs the various waves equally, but not totally, is grey; while a body which absorbs the various waves unequally is *coloured*. Colour is due to the extinction of certain constituents of the white light within

the body, the remaining constituents, which return to the eye, imparting to the body its colour . . A body placed in a light which it is incompetent to transmit appears black, however intense may be the illumination. Thus a stick of red sealing wax placed in the vivid green of the spectrum is perfectly black. A bright red solution similarly placed cannot be distinguished from black ink ; and red cloth, on which the spectrum is permitted to fall, shows its colour vividly where the red light falls upon it, but appears black beyond this position . . . . . ."

Q. 601.—Describe the different uses to which double convex lenses are put.

Ans.—(1) *Magnifying Glasses.*—Double convex lenses are used as magnifying glasses. A magnifying glass is nothing more than a double convex lens mounted on a frame and provided with a handle. The magnifying power of a lens depends upon its refracting power. These magnifying glasses, by a proper combination of them, can be made to magnify an object even 500 or 600 times, so that objects that can hardly be seen with naked eyes can be clearly and distinctly seen with this instrument. Such

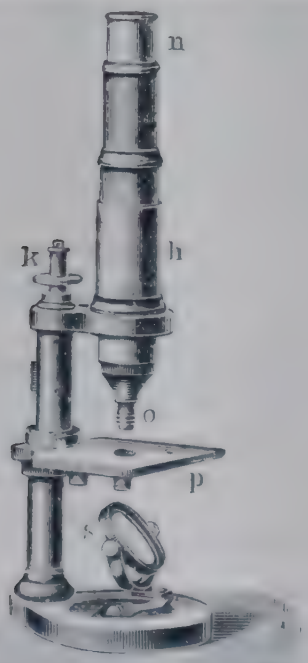

Fig. 76.

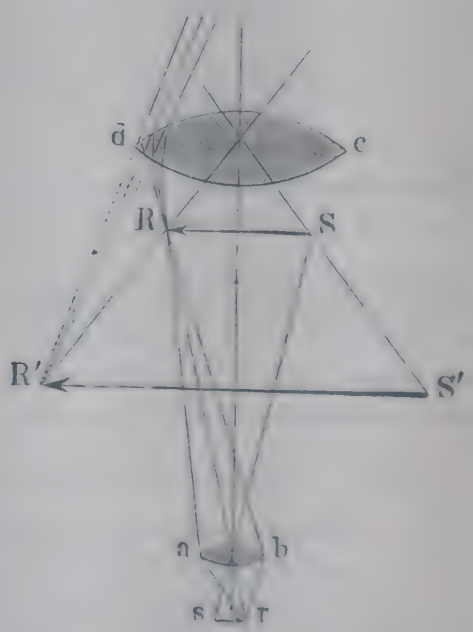

Fig. 77.

an instrument is called *a compound microscope*. A magnifying glass may be called *a simple microscope*.

Fig. 76 illustrates the form of compound microscope. The object to be examined is placed on P and looked at through *n*. That which is marked **S** is a mirror and it can be so adjusted as to throw the required light on the object to be examined. Fig. 77 illustrates how a compound microscope magnifies the object many times and makes it appear very large. The object *sr* is placed a little beyond the focus of the object glass *ab*. A large and real image of it is formed on the other side of the lens *ab* at RS. Now the eye piece *cd* is so adjusted that the image RS is brought between the lens *cd* and its focus. The image RS is magnified and appears as R'S'.

(2) *Light-houses.*— In the case where the object is in the focus of a lens no image of the object will be formed, for the rays from the object after passing through the lens proceed in parallel pencils. In light-houses this property of lenses is of very great use. Strong lights are placed in the focus of a double convex lens behind it. The light after passing through the lens proceeds in parallel pencils, so that it can be seen by mariners at a great distance.

(3) *Photography.*—Since double convex lenses form real images of objects presented to them, they are of essential service in Photography. [Read Q. 602.]

(4) *Telescopes.*— By a proper arrangement of them, lenses enable us to see clearly things at a very great distance. Such an arrangement is called a telescope. A telescope, in its simplest form consists of two double convex lenses placed at a proper distance from each other. One of these lenses, which is to be directed towards the object to be seen, is called the *objective*; the other lens, *through which the observer looks at the image formed*, is called the eye-piece marked *o* in fig. 74. When the *objective* is presented to the distant object, a small and inverted image of it is formed on the other side of the lens. This image is looked through the eye-piece so that the image may be magnified. These lenses are mounted in tubes, and there is an arrangement by which the tube carring the eye-piece can be made to move forwards or backwards. By this arrangement we can move the eye-piece forwards or backwards so that the image may come between this lens and its focus. The distant object is thus clearly seen. See figure 74.

Q. 602.— What is photography? State the various parts of a photographic apparatus and describe the process.

Ans.— Photography is the art of fixing the images of objects on substances, sensitive to light. The various parts of a photographic apparatus are

(1) a camera. (2) a lens, and (3) a stand. The camera is a box, in the front part of which there is a sliding tube containing a lens or a number of lenses. The back part of the box is a ground glass-plate which can be moved forwards or backwards. Thus, the tube as well as the back part of the box are movable.

Operation.—The tube of the camera is presented to the object the image of which is to be taken. The rays from the object after traversing the lens fall on the ground glass-plate at the back of the camera and form an image there. The tube containing the lens is moved forwards or backwards until a clear image of the object is obtained. The adjusting of the lens to get a clearly defined image of the object is called 'focussing.' After getting such an image the ground glass-plate is removed and another glass-plate (which is smeared over with a substance very sensitive to light, and which the photographer carries in a closed and light-tight box) is introduced in its place. The light rays from the object act on the substance of the plate and bring about a change in it; the change on it will not be the same throughout, but will be different parts according to the intensity of the reflected light.

The change which light produces in bodies is *instantaneous in some substances* (for example, a paper smeared over with silver chloride is blackened soon on exposure to the sun) and slow in others. The glass-plates used in photography are smeared over with some such sensitive substance. Let us see what happens to such a glass-plate when exposed in a camera. Suppose the object presented to it is white in the upper part and black in the lower part. Since white things reflect light much more than black ones, the upper part of the object sends to the sensitized glass-plate more light rays than the lower part. The glass-plate also is affected accordingly and the image on it will be black where the object is white and white where the object is black. The image on the glass-plate is thus reversed in colour and is called a ***negative.***

This negative undergoes three processes before an exact image of the object is obtained. The first is *developing.* The plate is taken into a dark room and there a solution called 'the developer' is poured on it. The effect of this is that the image is developed. The next process is *fixing.* After the image is well developed, it is washed and placed in a solution of alum which hardens the film on the plate. It is then washed again and placed in a solution of sodium hyposulphite by which the image is fixed. It is then varnished. The third process is *Printing.* Underneath this negative a paper coated with a sensitive substance is placed and exposed to the sun's light. Through the black parts of the negative

little light passes, and through the white parts more light passes. Hence the parts of the paper under the white portions of the negative are blackened, while the parts of the paper under the black portions remain white. The black parts of the negative come out as white and *vice versa*. We thus obtain the correct image of the object, on the paper.

ELECTRICITY.

Q. 603.—Describe the construction and use of an electric pendulum.

Ans.—Electric pendulum consists of small ball of a light substance called pith, attached to a glass stand by means of a silk thread (fig. 78). It is used to ascertain the presence of electricity on any substance.

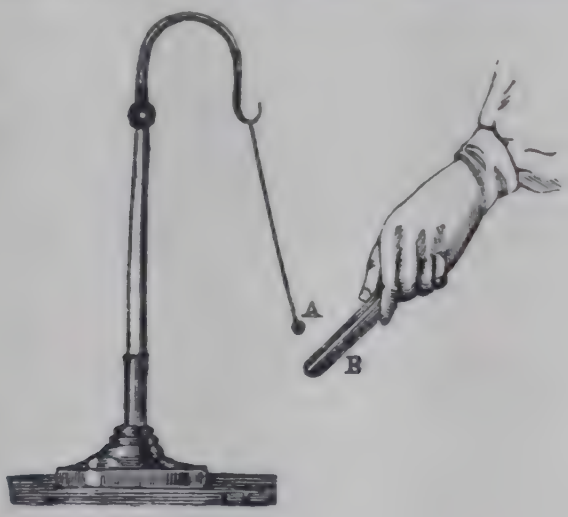

Fig. 78.

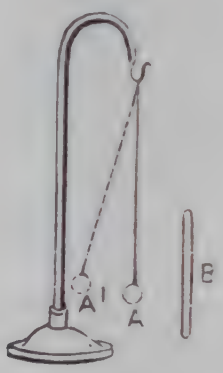

Fig. 79.

Q. 604.—State four of the ways in which electricity may be produced.

Ans.—(i) By friction:—Electricity produced by this means is called frictional-electricity. (ii) By chemical action:—Electricity is produced when some chemical actions take place. (iii) By magnetism:—Electricity produced by means of magnets is called magneto-electricity. (iv) By heat:—Electricty produced by heat is called thermo-electricity.

Q. 605.—You are given two glass rods, a piece of flannel, a piece of silk, and an electric pendulum. State what facts concerning electricity may be learnt with the help of these and how ?

Ans.—Facts that may be learnt with the help of the things given are

(i) Electricity is produced on a glass-rod not only when rubbed with flannel but also when rubbed with silk.

(ii) Electricity is capable of being transmitted from one body to another by actual contact.

(iii) The electricity produced on a glass-rod when rubbed with flannel is *of a different* (and opposite) kind from the electricity produced on another glass-rod rubbed with silk; because the pith ball possessing the electricity of the glass-rod rubbed with flannel, is repelled by this glass-rod but is attracted by *another glass-rod* possessing the electricity produced on it by being rubbed with silk.

(iv) Bodies possessing similar kinds of electricity on them repel one another; while bodies containing dissimilar kinds of electricity on them attract one another.

How these facts could be learnt :— Rub the glass-rod with flannel and present it to the pith ball of the electric pendulum. The ball will be attracted (fig. 78), and after a second or two it will be repelled (fig. 79). If you take the same glass-rod nearer to the ball *after it is repelled*, you will see that it will not at all be attracted but repelled further. What is the reason? The reason is that when the glass-rod was rubbed, electricity was produced upon it and so the pith ball was attracted. Then when the ball came into contact with the glass-rod *a part of the electricity on the rod passed to the pith ball* and hence the pith-ball was not attracted by the rod. To the pith ball thus repelled, present *another* glass-rod, previously *rubbed with silk*. The pith ball instead of being repelled, rushes to this glass-rod. We know that electricity is produced on a glass-rod also when it is rubbed with silk.

Q. 606.—How can you show that if you rub a glass rod with a piece of silk one kind of electricity goes to the glass and the other kind to the silk.

Ans.—It can be shown by means of an experiment similar to that devised by Faraday. A small silk cap provided with a silk thread will be fitted on to the end of a stout glass-rod and rubbed round a few times. Then the cap will be removed by means of the silk thread and the glass-rod as well as the cap will be presented successively to a positively charged pith ball pendulum. There will be repulsion in the one case and attraction in the other, showing that glass-rod possesses a different kind of electricity from that of silk.

little. *Q.* 607.- Describe an experiment for showing that there are two kinds of electricity.—M.U., 1881 ; 1901.

Ans.—Rub a glass-rod with silk till electricity is generated and touch the pith ball of the electric pendulum with it. The ball will first be attracted and, after remaining in contact with the rod for a short time, will be repelled ; because the ball takes up a part of the charge on the glass-rod. If the glass-rod be taken to that, it will not be attracted, but will be repelled as in figure 79.

Now, present to this ball a sealing wax rod, on which electricity has been generated by rubbing it with flannel. The pith ball rushes to it.

Thus it will be seen that there are two kinds of electricity—one, produced on the glass rod rubbed with silk and the other produced on the sealing wax rod rubbed with flannel [Cf. Q. 605.]

Q. 608.—Explain the terms : charge, conductor, non-conductor, discharged, positive electricity and negative electricity.

Ans.—Charge.—"The quantity of electrification of either kind produced by friction or other means upon the surface of a body is spoken of as a charge.

"Those bodies that allow electricity to pass through them readily or nearly so, are called conductors.

"Those that offer resistance to the passage of electricity through them are called non-conductors.

"When the charge of electricity is removed from a charged body, it is said to be discharged."

Positive electricity means the electricity *produced on the glass-rod* rubbed with silk or the electricity that is precisely like it.

Negative electricity means the electricity produced on a sealing-wax rod rubbed with flannel or the electricity that resembles it.

Q. 609.—State the law regarding the action upon one another of electrified bodies, and describe how it may be demonstrated—M.U., 1899.

Ans.—The law.—Bodies charged with similar electricity repel each other, and bodies charged with dissimilar electricity attract each other.

How it may be demonstrated. Touch the pith ball of an electric pendulum by a glass rod rubbed with silk ; present to the same pith ball

another glass-rod similarly charged; the pith ball will be repelled. Now present to the pith ball a sealing wax rod charged with electricity produced by friction with flannel. The pith ball will be attracted, showing that dissimilar electricities attract each other.

Q. 610.—State, and account for, the different names by which non-conductors are known.

Non-conductors.—Because they do not allow the free passage of electricity through them, they are called non-conductors.

Insulators.—As non-conductors resist the passage of electricity through them, they are used as supports for electrical apparatus, so that the electricity produced on the apparatus may not escape. When a conductor is provided with a non-conducting support, that conductor is said to be *insulated*. 'Insulator' is 'that which detaches thing, so as to have no communication with surrounding objects.'

Dielectrics.—On account of the peculiar property which non-conducting substances possess, namely, of allowing the influence of an electrified body to act across them on other bodies and induce electricity in them, non-conductors are called dielectrics.

Q. 611. A piece of metal, attached to a glass-rod, is electrified by friction. How would you ascertain with what kind of electricity it is charged?—M.U., 1900 R.

Ans.—Touch the pith ball of the electric pendulum with the piece of the metal. The ball acquires the charge of the metal and will be repelled. Now take a glass rod rubbed with silk to the pith ball.

If the ball be attracted, the charge on the ball must be taken to be dissimilar to that on the glass rod is negative and, so, the charge on the piece of metal also must be taken to be negative. If, however, the ball be repelled, the charge on the ball must be supposed to be the same as that on the excited glass-rod, *i.e.*, positive, and hence, the charge on the metal piece also must be positive.

Q. 612.—In electrification by friction, how would you show that (1) the rubber as well as the thing rubbed are electrified oppositely and (2) the quantities are equal?

Ans.—If the rubber is well insulated previously to the rubbing, it will also be found to have acquired the power of attracting light things just like the glass-rod, in other words, the rubber also will be electrified. If the

ll of an electric pendulum be presented to a rubbed glass-rod, the little ushes to the rod and after being in contact with the rod for a while the w s away from it, because it will be charged with the same electricity and bodies charged with the same kind of electricity repel one another. If now to this repelled pith ball *the rubber* be presented, the balls will rush to it. Thus the electricity produced on a glass-rod, when rubbed, is opposite to the electricity on the rubber. If the electricity on the rubber as well as the electricity on the thing rubbed be imparted to a third body, the third body will have no signs of electrification at all. This shows that the opposite kinds of electricities produced on the rubber and the rubbed are exactly equal in quantity, they having exactly neutralised each other in the third body.

Q. 613.—Describe an experiment to prove that when I bring an insulated conductor charged with electricity near to another insulated conductor, two opposite kinds of electricity are induced on opposite sides of the latter?—M.U., 1887.

Ans. Hold an insulated conductor AB opposite to an electrified body c, fig. 80. Let c be charged with positive electricity. The charge on c acts inductively on AB across the layer of air, and induces electricity on A as well as on B. If before bringing AB near c we suspend by cotton

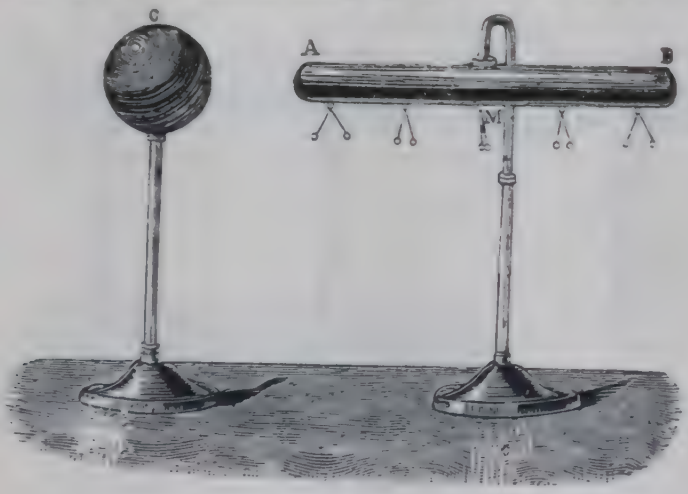

Fig. 80.

threads pairs of pith balls, at different distances along BA, when the charged body c is brought near it, these pairs of pith balls at different parts of AB will be seen to diverge, for they receive the electricity on AB through the cotton threads, which are conductors of electricity, and being charged with similar electricity repel each other.

The charge on A will be negative and that on B positive. To find this touch B with an insulated metal disc and present it to the pith ball of an electric pendulum charged positively. The ball will be seen to be repelled. This shows that B is charged positively. Next, touch the body A with your finger. The charge on B escapes to the earth and that on C remains. Now, remove your finger and then remove C. Touch A with an insulated metallic disc and present it to the ball of an electric pendulum charged positively. The ball will be attracted showing that B has negative charge.

Q. 614.—What is electrical induction? (*b*) How could you experimentally show that the quantities of positive and negative electricities simultaneously induced are equal?—M.U., 1894.

Ans.—The way of producing electricity in an adjacent conductor by the influence of a previously electrified body across a non-conducting medium is said to be electrification by influence. It is also called electrification by induction or electrical induction.

Hold an insulated conductor BC opposite to the positively charged body A (fig. 81). Let BC be made of two parts capable of being

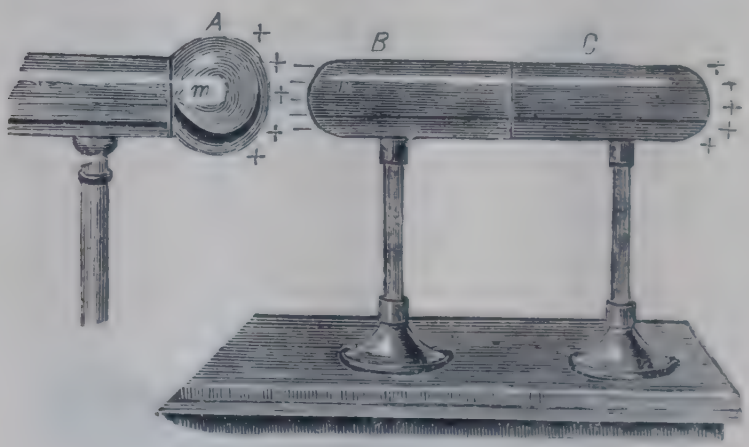

Fig. 81.

separated from each other in the middle. The charge on A acts inductively on BC and there will be negative charge on B and positive charge on C. While BC is under the influence of A, separate BC. B will now be found to have negative charge, and C, the positive. Next take away A and bring B and C together. BC will not have signs of electricity at all, showing that the opposite charges on B and C united and neutralized each

As the charges on B and C neutralized each other, they must be found to be equal.

Q. 615.—State the points of difference between electrification by conduction and electrification by induction.

Ans.—

Electrification by Conduction.	Electrification by Influence.
1. The charging body parts with some of its electricity.	1. The inducing body does not lose even a small quantity of its charge.
2. The electricity imparted to the other body is of the same kind as that on the previously charged body.	2. The induced body will have the opposite kind of electricity.
3. Both the bodies must be brought into actual contact.	3. The previously charged body and the body to which electricity is to be imparted by induction must be separated by a non-conducting medium.

Q. 616.—Explain the terms 'bound charge,' 'free charge' and 'neutral line.'

Ans.—*Bound charge* is the name given to the electricity on the body subject to induction on the side nearer to the inducing body (on B fig. 81), while the charge on the farther end is called *free charge*.

The place in the induced body, where the signs of electrification are completely wanting, is called the *neutral line*. It is not exactly in the middle, but a little towards the inducing body. [Fig. 80.]

Q. 617.—Describe and explain the method of charging a conductor by induction.

Ans.—Insulate the given conductor. Take it near to an electrified Body. While the conductor is under the influence of the electrified body touch it. Next, remove your finger and then take away the conductor from the electrified body. This way of charging a body is called '*charging by induction or influence*,' and in this method of charging, the body to be charged will have a kind of electricity which is opposite to that on the previously charged body

Explanation.—The electricity on the charged body induces both the kinds of electricity in the given conductor. When touched, the free (like) charge escapes to the ground. The bound (unlike) charge remains on the given conductor and spreads over it when separated from the electrified body.

Q. 618.—On what does the quantity of electricity induced in a body depend?

Ans.—In electrification by influence (or induction) the amount of electricity induced depends (i) on the amount of electricity on the previously charged body—the greater the charge on A, the greater will be the induced charges in BC (fig. 81). (ii) On the distance of the previously charged body from the body in which electricity is to be induced—the farther A is from BC, the smaller will be the quantity of the charge induced in BC. (iii) On the nature of the non-conducting medium that separates the inducing and the induced bodies—the electricity induced in BC will be greater when A and BC are separated by glass than when they are separated by a layer of the air of *the same thickness.*

Q. 619.—Describe the Gold-leaf Electroscope. How would you charge it with positive electricity, and then use it to find whether an electrified body is charged positively or negatively?

—M.U., 1884.

Ans.—*Description*:—An electroscope is an instrument by means of which we can find out whether a body is charged or not and, if electrified, the kind of the charge (fig. 82).

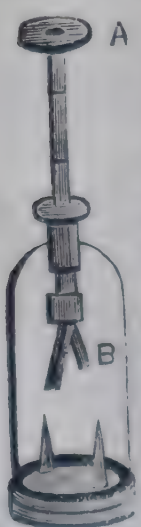

Fig. 82.

It is made in the following way:—(1) A piece of varnished glass tube is passed through the cork (which is also varnished) of a wide mouthed bottle. (2) A thick wire is passed through this tube. (3) This wire is provided with a brass plate above and has below a couple of gold leaves attached to it. The bottle serves two purposes—it protects the leaves from currents of winds and it insulates them. The instrument thus obtained is a very sensitive one. A rubbed glass-rod, even at a distance of two feet from the instrument, shows signs of electrification. Generally, leaves of Dutch metal, and sometimes tissue paper, are substituted for gold leaves in the above instrument. These make the instrument, no doubt, cheaper, but at the cost of its sensitiveness.

How to charge it positively.—Take a sealing wax rod rubbed with flannel to the knob of the gold-leaf electroscope. While under the influence of the charged body, touch the knob with your finger.

Then remove the charged body *after taking away your finger*. The instrument will be charged positively.

How to determine the charge on a given body.—Take the given body to the knob of the instrument the leaves of which remain diverging, being charged positively. If the leaves diverge still more, the inference is that the given body is positively charged; but if they collapse, the body is negatively charged. The body presented to the knob acts inductively on it and attracts the opposite electricity in the knob and repels similar electricity into the leaves. If the leaves diverge more, the body is charged positively; if the leaves collapse, the body contains negative charge.

Q. 620.—Explain how a gold-leaf electroscope may be charged with either positive or negative electricity by means of a glass-rod which has been rubbed with silk.—M.U., 1891.

Ans.—A glass-rod rubbed with silk acquires a charge of positive electricity on it.

To charge the gold-leaf electroscope positively, rub the glass-rod with silk, taking care that it is not strongly electified, and touch the knob of the instrument with this excited glass-rod. The leaves of the instrument will be seen to diverge thus showing that the instrument is charged. This way of charging the electroscope is said to be charging by conduction and the leaves will have a positive charge on them. To charge the instrument negatively proceed as follows:—Present the excited glass rod to the knob of the instrument. It acts by induction and attracts the negative charge in the knob and repels the positive charge to the leaves. Then touch the knob. The free (positive) charge on the leaves escapes to the ground and the leaves collapse. Now remove the finger from the knob, and then take away the glass-rod. The bound (negative) charge in the knob distributes itself and the leaves will diverge once more, but this time with negative electricity. This way of charging the instrument is said to be charging the electroscope by induction.

Q. 621.—*(a)* A stick of excited sealing-wax is brought in succession near the knobs of two charged electroscopes. The leaves of the first collapse, while those of the other diverge still

further. What is the charge on each electroscope? Give reasons for your answer.

(*b*) If a long, insulated conductor be now brought with one end near the knob of one electroscope, and the other end near the knob of the other, what effect will it produce on the indications of the electroscope?—M.U., 1896.

Ans.—The first electroscope has positive charge and the second, negative charge. When an electrified body is presented to the knob of a gold-leaf electroscope, it acts by induction and sends to the leaves a similar charge. Now, the excited sealing-wax rod must be taken to have negative charge on it. As the leaves collapsed in the first electroscope, they must have possessed unlike charge previously, *i.e.*, positive. As they diverged still more in the second, they must have possessed a similar charge previously, *i.e.*, negative.

(*b*) The leaves of both of the instruments may be seen to collapse. Both of these instruments act by induction on the *long* conductor. The first instrument induces negative and sends positive charge to the other end of the conductor. The second instrument induces a positive charge and sends the negative to that end of the conductor near the first instrument. The effect of those opposite charges near the knobs of the two instruments is to make the leaves of the instruments collapse.

Q. 622.—A sheet of copper is placed vertically between a positively charged conductor and the electroscope. How would the leaves be affected according as to whether the copper sheet is insulated or uninsulated?—M.U., 1898.

Ans.—(1) When the copper sheet is insulated, the free charge remains on it on the side nearer to the electroscope. This charge is positive and acts inductively on the knob of the instrument. Hence the leaves of the instrument diverge.

(2) As the sheet is uninsulated, the free charge escapes to the earth and the leaves of the instrument remain unaffected.

Q. 623.—Could you determine the quantity of electricity on a body by means of a gold-leaf electroscope? Describe a simple form of the instrument by which this can be done.

Ans.—With the help of a gold-leaf electroscope we can only compare, though not accurately, the quantities of electrification on two bodies, by noticing the extent of divergence in the leaves, caused by these two bodies separately. That which causes a greater divergence must have a greater charge on it. If these charges are to be compared with precision, we must have recourse to the instrument called *electrometers*. In one form, the electrometer "consists of a pith ball at the end of a light arm fixed on a pivot to an upright (fig. 83). When the whole is electrified, the pith ball is repelled from the upright and flies out at an angle, indicated on a graduated scale behind it." The repulsion of the pith ball can actually be measured, and thus the quantities of charges on different bodies may be precisely measured and compared.

Fig. 83.

Q. 624.—What is a proof-plane? How would you show that a charged body retains the charge only on its surface? —Pun. Ent., 1904.

Ans.—The *proof-plane* is an instrument which consists of a little disc of copper fixed at the end of a glass-rod and which is used to observe the nature of electricity upon a charged body by removing a small quantity of the charge to serve as a sample for examination.

Fig. 84.

Take an insulated hollow metal globe with an opening at the top. (Fig. 84). Charge the globe with electricity. Now touch the charged body anywhere outside by a proof-plane and take it to the knob of a gold-leaf electroscope. The leaves will diverge showing that the proof-plane received a charge from the part touched. Afterwards discharge the proof-plane and carefully insert it into the globe through the opening above and touch *any part inside*. Take it out carefully and present it again to the knob of the electroscope. The leaves do not diverge, showing the absence of the charge anywhere inside. Therefore we infer that in a charged body electricity resides only on the surface.

Q. 625.—"On the surface of charged bodies the distribution of electricity is not uniform, but is different in different parts, according to the shape of the body." Explain how this could be ascertained, and state how it distributes itself on (1) a sphere and (2) an oval body.

Ans.—If you touch *any part of a charged body* with a proof-plane and take it to an electrometer, you will be able to observe that the proof-plane possesses a certain quantity of electricity on it. Thus, you ascertain the quantity of the charge *on that part of the charged body.* Now discharge the proof-plane and then touch another part of the body and examine the quantity of the charge now received by the proof-plane in the same way as before. Suppose you observe a greater quantity of charge on it, this time. The inference must be that at different parts of the conductor, the quantity of the charge is different, in other words the distribution of the charge on it is not uniform throughout.

Experiments made in this manner on charged bodies of different shapes showed that when a spherical shaped body is charged, the charge distributes itself uniformly throughout ; but if the charged conductor possesses edges and corners, the distribution of the charge on such a body will be different in different parts.

(1) On an insulated charged sphere the electricity distributes itself uniformly all over it. (2) On an oval conductor the accumulation of the charge will be greatest at the narrow parts. The dotted lines in figs. 85 and 86 show the distribution of electricity on those two bodies.

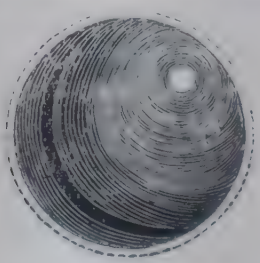

Fig. 85.

Fig. 86.

Q. 626.—Illustrate the statement that '*a charge of one kind of electrification always induces a charge of the opposite kind*' by describing as exactly as you can, the positions and motions of the charges in the following operations:—(*a*) A stick of negatively electrified sealing wax is held over the cap of a gold-leaf electroscope ; (*b*) the cap is touched for a moment ; (*c*) the sealing wax is removed.—**Lon. Mat., 1902 June.**

Ans.—(*a*) The sealing wax rod acts by induction on the instrument, induces the opposite kind charge on the cap, and drives out the like to the leaves. Hence, the cap possesses the positive charge; the leaves receive the negative charge and remain diverging.

(*b*) The free charge (negative) on the leaves escapes through the body. The leaves will be seen to collapse. There is now only the positive charge (bound) on the cap.

(*c*) The bound charge spreads over the cap and the leaves. The leaves will be seen to diverge once more, but this time on account of negative charge.

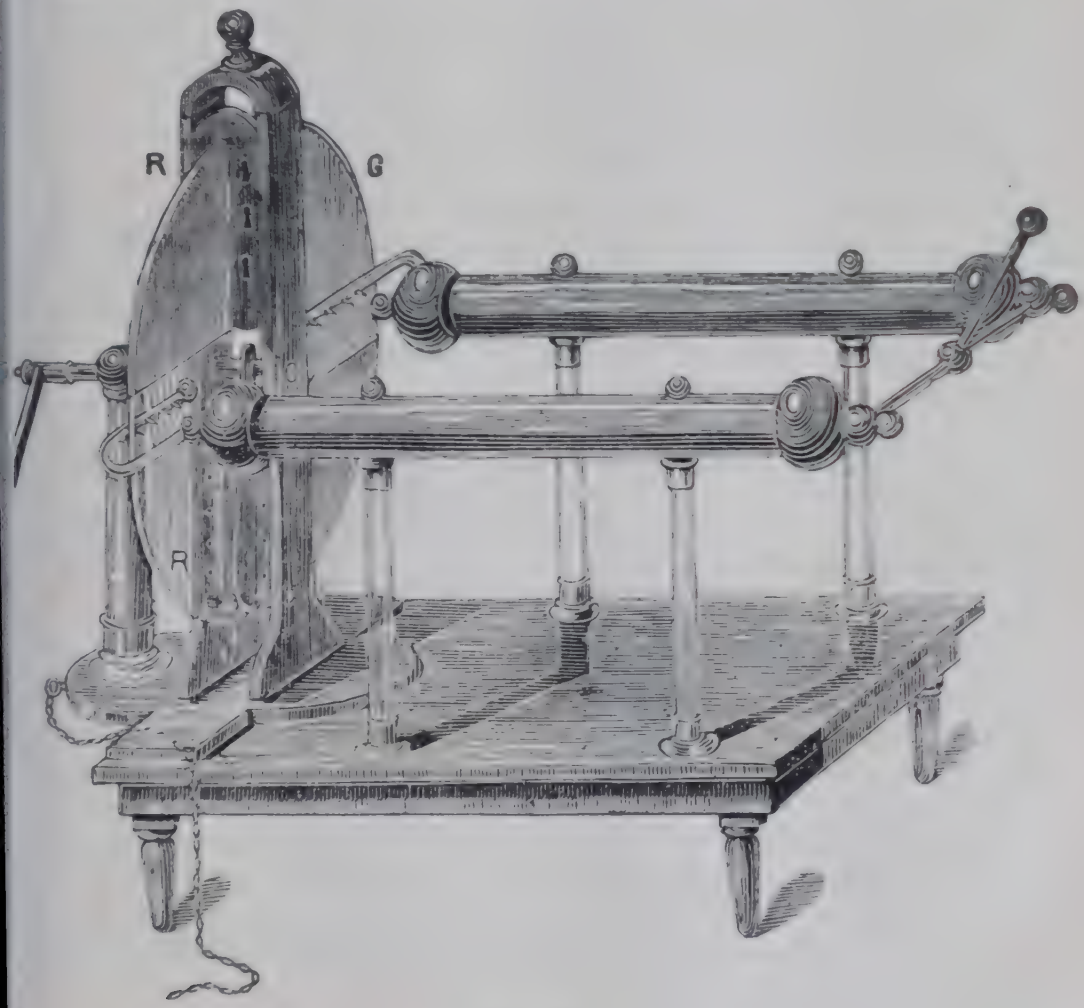

Fig. 87.

Q. 627.—Describe any form of machine for producing electricity by friction, and explain its action.—M.U., 1895.

Ans.—The Plate Electric Machine. *Its parts*: —(1) A circular glass-plate G, fig. 87, turning by means of a handle H pressing against two sets of rubbers in its turn (RR) and passing through two bent brass rods which are shaped like a horse shoe and provided with points *which face the glass-plate.*

(2) Two insulated metallic cylinders connected with each other and also with the bent brass rods, to collect the electricity produced. These are provided with a knob which forms the prime conductor of the machine.

(3) A chain connecting both the rubbers with the ground.

Its action:—(1) Turn the glass-plate by means of the handle. By the friction of the rubbers with the glass-plate in its course positive electricity is produced on the glass-plate and the negative on the rubbers.

(2) The negative electricity on the rubbers goes away to the ground, being connected with it by a chain.

(3) The positive charge on the glass-plate comes in its turn opposite to the bent brass-rod provided with points. Here, it acts inductively upon them, attracts the opposite kind of charge, (*i.e.*, the negative charge) on the near side (*i.e.*, in the points), and repels the like kind (*i.e.*, the positive charge) to the prime conductor, where it collects.

(4) The negative charge induced cannot accumulate on the points. Therefore the points lose the charge on them by sending streams of negatively electrified air to the glass-plate passing before them.

(5) These streams of negatively electrified air neutralize the positive charge on the glass-plate; so that the glass-plate will be neutralized and be ready for action by the time it goes to the other set of rubbers.

Q. 628.—Why is it impossible to charge a conductor provided with a point?

Ans.—If a pointed conductor is charged, the charge tends to accumulate at the point: the accumulation goes on to such extent that the body cannot retain it: because the particles of the air in contact with the point will be electrified and repelled. Fresh air taking its place is similarly electrified and repelled. In this way a charged conductor with a point loses the charge on it. A conductor provided with a point cannot be charged for this reason. If we want to charge a conductor it must be free from points of any kind.

Q. 629.—What experiments have you seen to illustrate the similarity of the electricity of an electrical machine and that of thunder cloud?—M.U., 1900.

Ans.—(1) If a finger is presented to the prime conductor of an electric machine at work a striking phenomenon will be seen—a bright spark will pass between the finger and the prime conductor, and at the same time the man feels a shock. In a discharge of lightning also, we notice a flash, and the effects of it are destructive.

(2) Present a spherical conductor to the prime conductor of an electric machine at work. Sparks will pass between the two; but no sparks will pass if the spherical conductor be provided with a point for the induced electricity does not accumulate on the conductor but is discharged. So also, if a building is provided with a lightning conductor, it will be safe from the destructive effect of the thunder.

Q. 630.—Explain how thunder and lightning are caused.

Ans.—Thunder and lightning are due to the discharge of electricity between the oppositely electrified clouds, or between the clouds and the earth (fig. 88). The source of electricity in this case is evaporation. "The evaporation of liquids is often accompanied by electrification, the liquid and the vapour assuming opposite states." Evaporation takes place in nature on a large scale, and vapour is in this way charged (and, therefore, also the clouds) with electricity. These clouds thus charged with electricity, act *by influence* on the earth below, when they pass over it, and induce the opposite kind of charge on it (fig. 88). When the attraction between the charge on the clouds and the opposite charge on the earth is sufficiently great—great enough to overcome the resistance of the intervening medium—they combine with great force, destroying anything in its way and giving rise to a big spark which is called lightning, and a loud noise which is called thunder.

Fig. 88.

Q. 631.—What is a Lightning Conductor? Explain its action. —M.U., 1903; Pun. Ent., 1900. State the conditions for a good conductor.

Ans.—Lightning conductor is an arrangement to protect buildings from the destructive effects of lightning discharge. An arrangement, for a perfect lightning conductor, must have the following characteristics :—

Fig.. 89

(1) It must be made of good conducting material and must end in a fine point. This point must not merely be above the highest point of the building, but must be carried to all high points (fig. 89). "It is unwise," says Prof. Thomson, "to erect very tall pointed rods projecting several feet above the roof."

(2) "All parts of a lightning conductor should be of one and the same metal, avoiding joints as far as possible, and with as few sharp bends or corners as may be. The use of copper . . . is needless . . . Iron is far better. Ribbon is slightly better than round rod."

(3) The other end of the conductor must pass into a good conducting stratum of the earth. It may be passed into a stream (or into a wet stratum).

(4) The conductor must be of sufficient thickness.

How the Lightning Conductors prevent Lightning : The action of a lightning conductor is precisely similar to that of the points in an electric machine. A lightning conductor does not allow the accumulation of the opposite kind of electricity induced on the earth. The electricity induced on the ground by a passing cloud is not allowed to be there by the pointed conductor. The conductor discharges it and sends streams of electrified air into the atmosphere. Thus the opposite charge induced on the ground is discharged and the charge *on the clouds alone* cannot produce lightning or thunder. A lightning conductor, therefore, prevents lightning by not allowing the electricity induced on the earth by the charged clouds to accumulate.

Q. 632. Define energy, and state how you would show that the electrification produced by friction satisfies your definition. —M.U., 1897.

Ans.—Energy is the power of bodies to overcome resistance.

A glass rod rubbed with silk acquires the power of raising bits of paper or of pith from the earth. This is due to the electrification on it. Electrification on the glass rod makes it overcome the resistance of gravity and draw bits of paper to itself.

Q. 633.—What are influence machines? How do they differ from frictional machines? Give, in general, the parts of an influence machine.

Ans.—In influence machines the electricity collected is obtained by the process of induction; in frictional machines electricity is generated by friction. In general, the parts of an influence machine are as follow:—

(1) Bodies possessing initial charges of opposite electricities.

(2) Substances that are subjected to the inductive influence of these electrified bodies.

(3) An arrangement to remove one of the two kinds of electricity induced in these substances and retain the other.

(4) Two rods ending in knobs to collect the charges retained by these substances.

Q. 634.—Explain what you would do (i) if a conductor is not to retain the electricity imparted to it and (ii) if a conductor is to hold more than its ordinary measure of electricity.

Ans.—*If a conductor is not to retain the electricity imparted to it*, all that we have to do is to make the conductor a pointed one, or to provide this conductor with some points. If this be done, the conductor does not retain the charge imparted to it, however strongly you may charge it, and the reason for this you know already. On the other hand *if a conductor is to have more electricity* on it than what it can hold under ordinary circumstances, this can be done by a special arrangement. If, for example, two pieces of tin-foil, one of which is connected with the ground and the other to the prime-conductor of an electric machine, be attached to the opposite faces of glass-plate, they can be charged more strongly than either of them could possibly be if charged separately. Such an arrangement is called a *condenser of electricity*. It was formerly called an accumulator.

Q. 635.—Describe a Leyden jar and explain its action. —All. U., 1902.

Ans.—The Leyden jar, called after the city where it was invented, is a convenient form of condenser. It usually consists of a glass-jar coated up *to a certain height* on the inside and outside with tin-foil. A brass knob fixed on the end of a stout brass wire passes downwards through a lid or top of dry well-varnished wood and communicates by a loose bit of brass chain with the inner coating of foil. (Fig 90.)

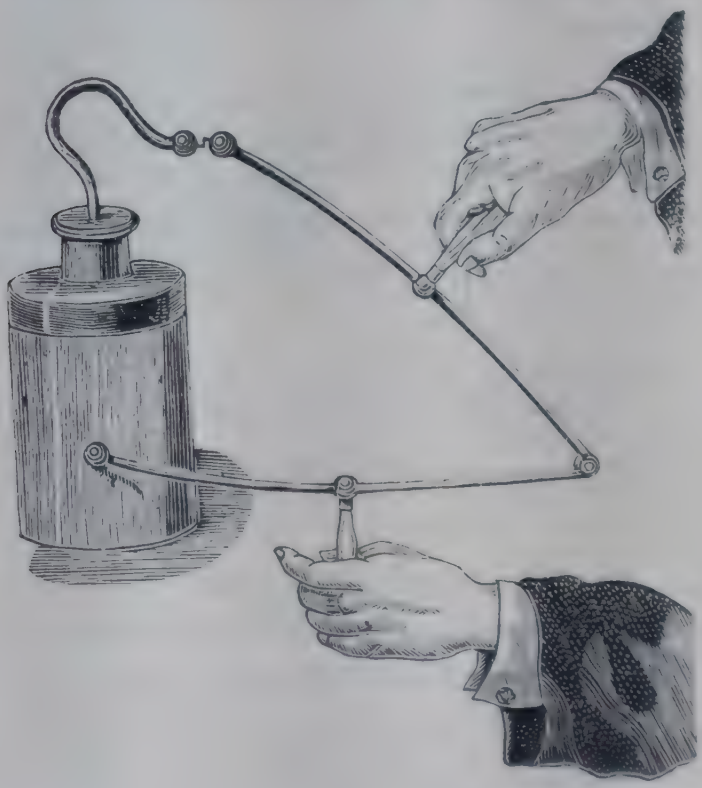

Fig. 90.

How to charge a Leyden jar. — "To charge the jar the knob is held to the prime conductor of an electrical machine, the outer coating being either held in the hand or connected with 'earth' by a wire or chain. When a positive charge of electricity is imparted thus to the inner coating, it acts inductively on the outer coating, attracting a negative charge into the face of the outer coating nearest the glass and repelling a positive charge to the outside of the outer coating and thence through the hand or wire to earth. After a few moments the jar will have acquired its full charge, the outer coating being negative and the inner, positive."

Q. 636.—How can we prove that the outer coating of a Leyden jar is oppositely electrified to the inner coating? —M.U., 1890.

(1) Let one knob of *the discharger* be laid against the outer coating of the Leyden jar and the other knob be presented to the knob of the jar. (Fig. 90). A spark leaps from one to the other and the jar will be discharged. Since a spark can be had only when the opposite charges unite, the charges on the two coatings must be considered to be opposite.

(2) Impart, first, the electricity on the knob of a charged Leyden jar to the leaves of an electroscope by means of a proof plane. The leaves remain diverging. Discharge the proof plane and then touch the outer coating of the jar by the proof plane; present this to the knob of the electroscope; the leaves will collapse denoting the presence of opposite electricity in the proof plane and hence in the outer coating of the jar.

Q. 637.—Describe the construction and use of a discharger; state how you would use a discharger without insulating handles, to discharge a Leyden jar.

Ans.—"A safe means of discharging the jar is afforded by the *discharging tongs or discharger*, which consists of a jointed brass rod provided with brass knobs and a glass handle. One knob is laid against the outer coating, the other is then brought near the knob of the jar (fig. 90) and a bright snapping spark leaping from the knob announces that the two accumulated charges have flowed together, completing the discharge." "If a discharger without insulating handles is used to discharge a Leyden jar, care should be taken to touch the outer coating first with one of the knobs of the discharger and then the other knob should be presented to the knob of the jar."

Q. 638.—A Leyden jar is strongly charged with electricity. How might you safely touch its knob while it is still charged? Explain.—M.U., 1893.

Ans.—With the help of a non-conducting material you may touch it; for, by insulating yourself, you will be separated from the earth, and though you touch the knob, you will not receive the shock, as the opposite electricities on the coatings do not combine through you.

Q. 639. Given a wide-mouthed bottle, what else would you require to make a Leyden jar, and how would you proceed to

make it? When a Leyden jar is discharged, what becomes of the energy?—M.U., 1886.

Ans.—Things required to make a Leyden jar :—

(1) Tin foil. (2) A metallic rod with a knob at one end and a chain at the other.

Coat the bottle to about two-thirds of its height both inside and outside with tin-foil. Pass the metallic rod through the cork of the jar so that the chain may rest on the inner coating.

When a Leyden jar is discharged, the energy of electrical separation is transformed partly into the light of the spark; the remaining part is converted into the heat of the spark and the sound that accompanies it.

Q. 640.—(*a*) Why can a Leyden jar not be charged in the ordinary way when it is placed on an insulating stand? (*b*) How do you charge it by an electrical machine when placed on such a stand?—M.U., 1892.

Ans.—(*a*) When a Leyden jar is charged in the ordinary way, the outer coating is held in the hand or is connected with the earth by a chain. Practically, therefore, there is a large scope for the inductive influence of the charge on the inner coating. The inner coating can receive the required quantity from the prime conductor of the machine and the outer coating can have the opposite charge on it to the required extent, being connected with the earth. But, if placed on an insulating stool, the outer coating is the only thing which is subjected to the inductive influence of the charge on the inner coating. Hence there is no possibility of accumulation of opposite charges as before.

(*b*) The outer coating must be brought into contact with any large conductor, or with the earth by a chain, or some other means.

Q. 641.—How would you arrange to give a simultaneous shock to a number of persons by means of a charged Leyden jar?

Ans.—A Leyden jar may be used to give a shock to a large number of persons simultaneously. The persons must be made to join hands so as to form a chain with its two ends near together. The person at one end of the chain must hold the jar in his hands while the other at the other end must touch the knob of the jar. The discharge takes place through all the persons forming the ring, and each of them receives a shock.

Q. 642.—Explain what is meant by the capacity of a conductor. Describe an experiment to prove that the capacity of an insulated conductor is increased by bringing near to it a second conductor connected with the earth.—Lon. Mat., 1902.

Ans.—The capacity of a conductor is "the power of a conductor to receive a charge of electricity."

Expt.—Take two metallic plates, A and B, supported on glass legs. First take A, separately, to the Electric Machine. Connect it with the prime conductor of the machine and work it. After some time A receives a charge from the machine, and the amount of this may be ascertained by means of an electrometer in connection with A. Note the amount of the charge. Then bring B, connect it with the earth by a chain, place it opposite to A, and then connect A with the prime conductor of an electric machine at work. If the quantity of the charge on A be now examined by the electrometer, it will show that a greater quantity of the charge has been received by it the second time.

Q. 643.—A hollow uncharged insulated vessel is connected with a gold-leaf electroscope. (*a*) A charged insulated metal ball is introduced into the vessel; (*b*) it is moved about within the vessel; (*c*) it is taken out of the vessel without touching it; (*d*) it is re-introduced and made to touch the inside of the vessel; (*e*) it is taken out again; (*f*) the vessel is finally connected to earth. Describe the effect on the gold leaves in each case.—Cal. U., 1904.

Ans.—(*a*) The charged ball acts by induction attracting the opposite charge on the interior of the vessel and repelling the like kind to the outside. This makes the leaves of the electroscope diverge.

(*b*) As the charged ball approaches the vessel, the electricity induced will be greater; and the greater charge outside the vessel will make the leaves of the electroscope diverge more.

(*c*) The opposite electricities induced in the vessel will reunite and make the vessel neutral. The leaves of the instrument therefore will collapse.

(*d*) The vessel is electrified by conduction; the leaves of the electroscope will diverge, being charged with the same kind of electricity as on the charged ball.

(*e*) The leaves of the electroscope remain diverging as the vessel remains charged.

(*f*) The vessel is discharged and so the leaves of the gold-leaf electroscope collapse.

Q. 644.—State the conditions upon which the capacity of a Leyden jar depends.

Ans.—(1) *The size of the jar.*—The bigger the jar the greater the amount of electricity that can be made to accumulate upon it.

(2) *The thinness of the intervening di-electric.*—The thinner the medium the greater the electricity induced and accumulated. But it must not be so thin as to give way and break when the jar is charged, under the stress set up in it owing to the attraction of the opposite electricities on each side of the jar.

(3) *The di-electric capacity of the intervening medium.*—A Leyden jar having glass for di-electric medium accumulates electricity much better than one of sulphur.

Q. 645.—Explain cell, battery, pole, local action, polarization, closing the circuit and binding screws.

Ans.—A *cell* is an arrangement to give a current, and in its simplest form consists of a plate of zinc and a plate of copper immersed in dilute sulphuric acid contained in a jar of glass or porcelain.

Fig. 91.

A number of cells joined together in the proper manner is called a *battery*. A voltaic battery is formed by taking a number of voltaic cells and connecting the copper pole of the first cell with the zinc pole of the second, the copper pole of the second with the zinc pole of the third, and so on by means of screws, known as binding screws (Figs. 92 and 93).

'*Pole*' is the end of the plate outside the liquid or of the wire connected with the plate. Closing the circuit is the joining of the free poles of the cells at the ends of a battery by a wire; when the circuit is closed a current passes through the wire.

The chemical action in a battery owing to the impurities in zinc is termed 'local action'; this causes a waste of zinc, and is remedied by amalgamating the zinc plates.

Q. 646.—Describe the battery first made by Volta.—M.U., 1886.

Ans.—Volta's battery is composed of a number of voltaic cells connected with one another in the proper manner. Each cell consists of a jar of glass or porcelain and contains dilute sulphuric acid with a plate of zinc and a plate of copper dipped in it. A battery with these cells is formed by connecting by a wire the zinc of the first cell with the copper of the second, the zinc of the second with the copper of the third, and so on. When the copper of the first cell is joined to the zinc of the last cell, the battery is closed and a current of electricity flows through the connecting wire. (Fig. 91.)

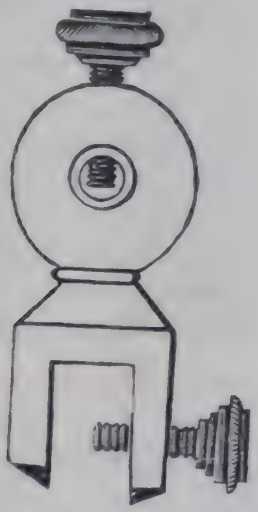

Fig. 92. Binding screws.

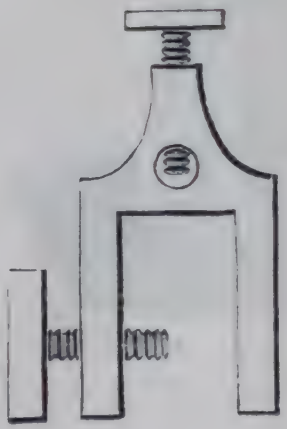

Fig. 93.

Q. 647.—What is the direction of the current in a cell? Distinguish between the positive plate and positive pole.

Ans.—The place from which the current starts is positive and the place to which it flows is negative. In a voltaic cell, zinc plate is positive

and copper plate is negative; copper pole is positive and zinc pole negative. The part of the metal in the liquid is called 'plate.' The direction of the current in the cell is shown in fig. 94 by an arrow.

Q. 648.—State the conditions to be fulfilled by a good battery.

(i) It must be free from polarization and local action.

(ii) The internal resistance must be small.

(iii) It must not be subject to any chemical action when the circuit is open.

(iv) It must be cheap and free from unhealthy fumes of any kind.

(v) It must give a strong and constant current.

Q. 649.—Sketch and describe briefly the arrangement of three Grove's cells to form a battery. Why should the zinc be amalgamated and why do we use nitric acid ?—M.U., 1887.

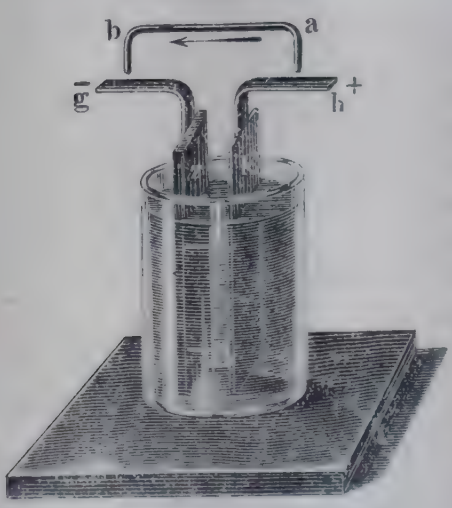

Fig. 94.

Ans.—The reason for amalgamating zinc is that local action may be prevented. Impurities in the zinc float to the surface of the mercury and are removed, so that a pure surface of zinc is always presented to the action of the acid. Impure zinc will be acted upon by sulphuric acid even when the circuit is open, *i.e.*, even though there is no current. This is a waste. Pure zinc is acted upon by the acid, only when the battery is closed. Amalgamation, therefore, prevents waste of zinc.

Grove's Battery.- Each cell of this battery consists of two flat vessels —an outer and an inner. The outer vessel is of porcelain (or glass) and contains a zinc plate immersed in dilute sulphuric acid. The inner vessel is a porous one, being made of unglazed earthenware and contains strong nitric acid into which a platinum foil dips. The chemical action in this cell is precisely the same as in the zinc-copper cell, but the hydrogen produced does not stick to the platinum foil, because when it tries to go to the platinum-plate it has to pass through the strong nitric acid in the porous vessel and combines with it forming water and nitrous fumes

Thus on account of nitric acid this cell is free from polarization. To form a battery with three cells, the platinum of the first is joined to the zinc of the second, and the platinum of the second to the zinc of the third by means of binding screws. (Fig. 102.) When the free pole of the first cell and the free pole of the last cell are joined by wires, the battery will be closed, the circuit will be complete, and a current begins to flow.

Q. 650.—State the advantage of Grove's battery over the Voltaic zinc-and-copper battery.—M.U., 1894.

Ans.—(1) It is free from local action and polarization. (2) The current produced is strong and constant. (A single cell will readily raise to a bright red heat 2 or 3 inches of thin platinum wire). (3) The internal resistance is small.

Q. 651.—What is the chief difference between the current obtained from Volta's and Grove's batteries? Explain the cause of their difference.—M.U., 1899.

Ans.—Electric currents obtained from Volta's battery are not steady in strength. They gradually become weaker. Moreover they are not so strong as those produced by means of Grove's battery.

Impure zinc used in Volta's battery is always acted on by the acid. This renders the acid weaker. In Grove's battery zinc plates are amalgamated. Hydrogen generated at the zinc plate collects at the copper plate in Volta's battery. This weakens the current on account of the resistance which hydrogen offers to the passage of the current. In Grove's battery the hydrogen has to pass through nitric acid before going to the platinum plate and the nitric acid destroys hydrogen. Thus this battery is free from this cause which weakens the current.

In Volta's battery zinc and copper are used in each cell. In Grove's, zinc and platinum are used: the strength of the current when zinc and platinum are used is greater than when zinc and copper are used.

Q. 652.—Explain how the action of Grove's battery would be affected if dilute sulphuric acid were substituted for the strong nitric acid which is used in it.—M.U., 1897.

Ans.—The resulting current will be very much weaker. The reason is this. Sulphuric acid does not absorb hydrogen as strong nitric acid does. Therefore when the circuit is completed the hydrogen liberated at

the zinc plate accumulates on the platinum plate. Hence, the current is weakened (1) because the platinum plate is covered by hydrogen; (2) the gas offers resistance to the passage of the currents, and (3) the gas sets up an opposite current (known as the polarization of the platinum plate).

Q. 653.—State the properties of electric currents and mention one important practical application of each.

Ans.—(i) *A current passing through a wire, heats it and even makes it red hot, if sufficiently strong.* On account of this property, electric currents are used for lighting purposes. (ii) *An electric current (if sufficiently strong) can decompose a compound liquid when passed through it. This property finds a practical application in decomposing liquids in electroplating.* (iii) *Electric currents magnetise an iron bar placed in a coil of wire through which they pass.* The practical uses to which electric currents are put on account of this property are many. Artificial magnets can be prepared by placing bars of steel in a spiral wire and causing a current of electricity to circulate in the wire. (iv) If an electric current is made to pass above or below a freely suspended magnetic needle and parallel to it, the needle is deflected, *i.e.*, the needle no longer points to north and south so long as the current continues to flow. The direction of the deflection depends upon the direction in which the current flows. The extent to which the needle is deflected depends upon the strength of the current. Hence electric currents are used to send signals by means of magnetic needles to distant places.

Q. 654.—Mention some of the uses to which electric currents are put in daily life.

Ans.—(1) Electric bells. (2) Telegraphy. (3) Telephony. (4) Electrotyping. (5) Electro plating. (6) Electro lighting. (7) For medical purposes. (8) Electric welding. (9) Electric gas lighting, etc.

Q. 655.—What is the difference between *electroplating* and *electrotyping*? Describe the arrangement of a plating vat.

Ans.—*Electro plating* is the process by which a thin layer of metal is made to adhere to an article made of an inferior metal, by means of electricity. Electro-typing is the process by which a metal, usually copper, is deposited on a prepared conducting mould so as to reproduce with accuracy the form from which the mould was taken.

Fig. 95 illustrates a plating vat. The article to be plated is attached to one of the metallic bars on the vat. To the other vat, the pure metal to be deposited on the article is attached. The article is connected with the negative pole of a battery, and the metal with the positive pole. The vat contains a suitable solution of the metal to be deposited. When the circuit is complete, the electric current passes through the solution and decomposes it. The metal is deposited upon the article which is connected with the negative pole. The other components of the solution combine with the metal, and the strength of the solution is thus maintained.

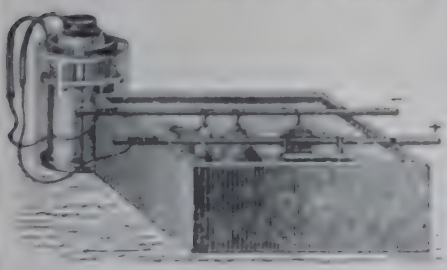

Fig. 95.

Q. 656.—Describe a method of decomposing water by means of a battery. At which plate does the hydrogen appear? —M.U., 1885.

Ans.—Take a funnel. Break off the stem and insert a cork. Through the cork pass two wires of the metal platinum. Pour water, to which a little acid has been added, into the funnel. Invert two test tubes filled with water over each of the platinum wires in the funnel. Connect the platinum wires to the poles of a battery. Electric currents can pass through the water in the funnel, because it is acidulated. As the current passes water in both of the tubes will be seen to be displaced by colourless gases. After a time you will see that in one of the tubes twice as much gas has collected as in the other. As soon as one of the tubes is full of the gas, take it out and, keeping it in the same position, apply a lighted match to the mouth.—a sharp report will be heard and a pale flame will appear at the mouth. This gas is hydrogen. Take the other tube which is found to heat only to half of it and turn it up. Now the upper half of the tube will deflect a glowing piece of wood into it. It is rekindled. The gas at the pole which is oxygen. Thus, we learn that water is made up of two parts of hydrogen and one part of oxygen by volume. In the decomposition of water by electricity, hydrogen collects at the negative pole and oxygen at the positive pole. (Fig. 96.)

Q. 657.—Explain electrolysis, electrodes, electrolyte, positive pole and negative pole.

Ans.—*Electrolysis* is the process of decomposing a compound by means of electricity.

Electrodes are the ends of the wire coming from the poles of a battery.

Electrolyte is a liquid that is capable of being decomposed by means of an electric current.

Positive pole is the end of the wire attached to *platinum*, copper, or carbon in a battery; this is also known as anode. Negative pole is the end of the wire attached to the zinc plate in a battery; this is also known as cathode.

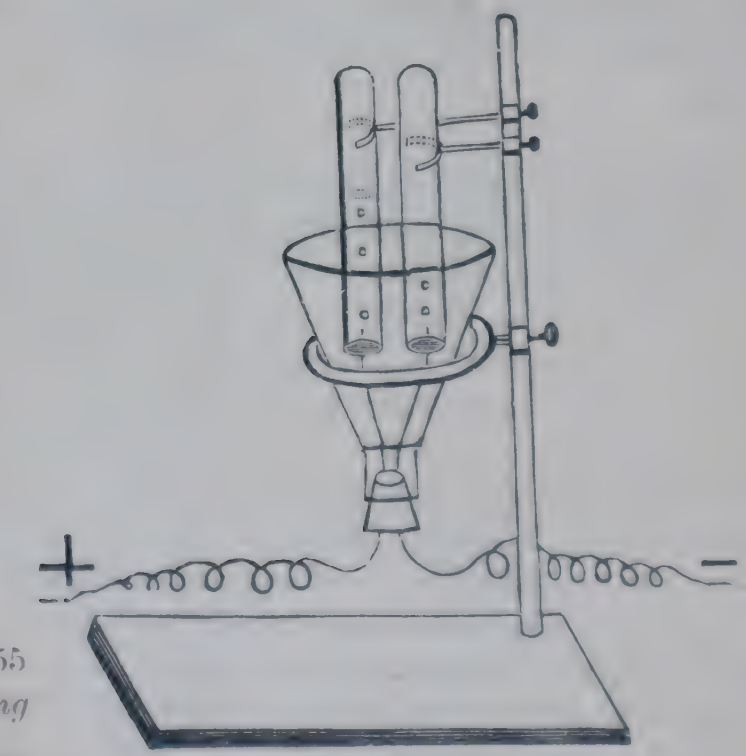

Fig. 96.

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Q. 655
electrotyping

Ans.—*Elec*
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—Describe any form of electric light.

re are many forms of electric lights. In one of these forms

Fig. 97.

the lamp contains a film of carbon specially prepared for this purpose and mounted upon a conducting wire. (Fig. 97). This is enclosed in a globe of glass from which the air has been completely removed; when the current passes through the conducting wires, the carbon film inside becomes red-hot or white-hot according to the strength of the current and gives good light. The film does not burn away, because there is no air inside the glass-globe; nor does it melt, for carbon is a substance which does not melt even at a higher temperature than what the electric current could raise it to. These are called *incandescent* lamps, because the light is obtained by the incandescence (white heat) of the carbon film in the globe.

Q. 659.—Describe a way of determining whether an electric current is flowing in a wire or not. If there is a current in the wire produced by a Grove's battery, how could you find which end is connected with the platinum plate of the battery?—M.U., 1891; Pun. Ent., 1900.

Ans.—Hold the wire parallel to and above or below a freely suspended magnetic needle. If the needle is deflected from its usual position of north and south, you infer the presence of a current in the wire. Next, notice the direction of the deflection in the needle. If the north seeking pole of the needle be deflected towards the west, the current in the wire must have been flowing from the south to the north, supposing the wire to be held above the needle. Thus the south end of the wire must be the one connected with the platinum plate and the other end with the zinc plate. So, by noticing the direction of the deflection of the needle and the position of the wire, we can know which end is connected with the platinum.

Q. 660.—A current from a Grove's battery is used to heat a thin platinum wire, to decompose water and to deflect a magnetic needle suspended underneath the wire. If the pole wire be now connected to the battery, so that the current goes through in the opposite way, what changes, if any, will be produced in the heating of the wire, the decomposition of the water and the deflection of the needle?—M.U., 1892.

Ans.—The heating of the wire continues as before, for the direction of the current does not affect its heating effect.

Water continues to be decomposed, but the gases will be collected in different places—hydrogen collects where oxygen was collecting and *vice versa*.

The magnetic needle will be deflected, but the direction of deflection will be reversed—if the north-seeking pole was deflected towards the west before, it will be deflected towards the east now, and *vice versa*.

Q. 661.—Explain the terms—(1) the poles of a magnet, (2) the north-seeking pole, (3) the south-seeking pole.

Ans.—(1) The ends of a magnet where the power of attracting iron is the greatest are called the Poles of a magnet. (2) That end of a magnet which points to the north when the magnet is freely supported is called the north-seeking Pole. (3) That end of a magnet which points to the south when the magnet is freely supported is called the south-seeking Pole.

Q. 662.—Give four examples showing that an electric current possesses energy.—M.U., 1890.

Ans.—(1) When passed into acidulated water, it decomposes the water. (2) When passed through a platinum wire, it makes it red-hot. (3) When passed through a coil of insulated wire in the centre of which an iron bar is placed, the bar becomes a magnet. (4) When passed above or below a freely suspended magnetic needle, and parallel to it, the needle is deflected.

Q. 663.—What is a magnet? How would you distinguish between a magnet and a magnetic substance?—Pun. Ent., 1900.

Ans.—A magnet is a substance which has the power of (1) attracting iron and (2) placing itself in a line joining North and South, when freely suspended.

Magnetic substances are those that can be attracted by a magnet, *e.g.*, iron and nickel.

I would take the given substance and freely suspend it. If it retains the position given to it, it would be taken not to be a magnet. But if it always tries to assume the direction of North and South when freely suspended, it would be taken to be a magnet.

Q. 664.—What are magnets made of? Describe how a magnet may be made, and how three of its magnetic properties may be shown.—M.U., 1900.

Ans.—Magnets are made of steel. Take the bar to be magnetised. Lay it flat and move the pole of a powerful magnet on the iron bar, taking care to move it always in the same direction. (1) Suspend a magnet by a silk thread freely. In a short time it places itself in the line running north and south. This shows that one end of the magnet always points to the north and the other to the south. (2) Place a magnet on a paper and pour iron filings along its length. On taking it out of the filings you will observe the filing adhering at the ends only, showing that the two poles attract iron and that the power of attraction is absent in the middle. (3) Present the north-seeking pole of a magnet to the north-seeking pole of the freely suspended magnet. It will be repelled. This shows that similar poles repel each other.

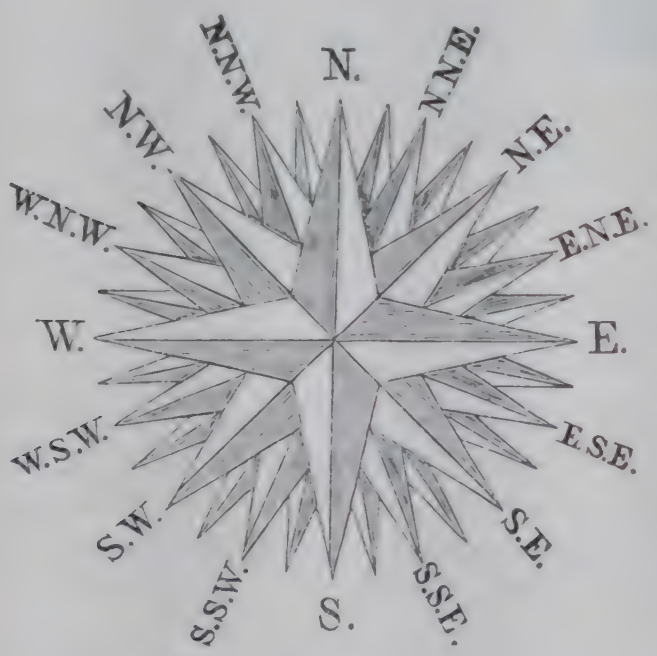

Fig. 98.

Q. 665.—Describe the mariner's compass.

Ans.—The mariner's compass is an instrument for guiding sailors. It consists of a magnetic needle mounted over a pivot, so that the needle may turn about its centre freely. Over this needle a round card is fixed with various directions marked on it (Fig. 98). The direction marked "North" corresponds to the north-seeking pole of the magnet beneath. The various directions marked on the round card thus point out correctly because the needle below always points to north and along with it, the card above.

Q. 666.—Describe an electro-magnet, illustrating your answer by a diagram. In what respects does it differ from an ordinary magnet.—M.U., 1895.

Ans.—If a soft iron bar is placed in the coil of wire, the bar becomes a magnet and remains so, only while the current flows through the coil; it ceases to be a magnet when the current ceases to flow through the coil. Such an arrangement is called an electro-magnet. (Fig. 99). An ordinary magnet retains its magnetism always and is made of steel. Electro-magnets retain their magnetism *only so long as the current flows round them* and are made of soft iron. They cease to be magnets as soon as the current ceases to flow round them. Electro-magnets are much stronger than the ordinary magnets.

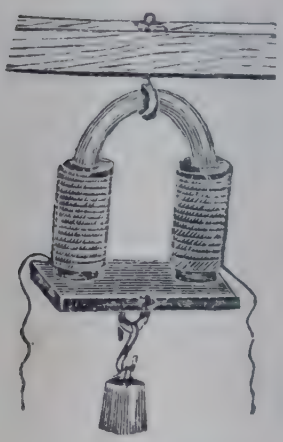

Fig. 99.

Q. 667.—Mention four different ways in which a signal may be sent to a distance by a current of electricity.

Ans.—Suppose a signal is to be sent from A to B. (1) Have an electric bell at B and connect it by wires with battery at A: or, (2) Have an electric light at B and connect it with a battery at A: or, (3) Have a vessel containing acidulated water into which wires are introduced. Connect these wires with the battery at A: or, (4) Suspend freely a magnetic needle in a coil of wire at B and join the ends of the wire with the poles of a battery at A.

Now, by having at A an arrangement whereby the current can be sent at will to B, a signal can be sent to B by each of the above means. In (1) the bell at B strikes when the current is sent: in (2) the light is seen in the lamp, and that is the signal: in (3) the water is seen to be bubbling, and that is the signal: in (4) the needle is deflected, and that serves as a signal.

Q. 668. Two similar pieces of steel are given, one of which is magnetised and the other not; also some silk thread. With this apparatus how can it be settled which is the magnet?—M.U., 1892.

Ans.—Suspend both of these by the silk thread. That which remains in any direction in which it has been suspended is to be taken to be ordinary steel. But the other which tries to place itself in the line joining north and south even when disturbed must be taken to be the magnetic piece of steel.

Q. 669.—Describe a magneto-electric machine.

Ans.—These are machines to produce currents of electricity by means of magnets. In these machines no acid or zinc is necessary. The presence of a permanent magnet is enough. In one form of these machines (used in hospitals generally) there is a permanent magnet bent like a horseshoe. Close in front of the magnet and near its poles, there are two coils of wires. By turning a handle, these coils can be made to revolve before the magnet, and this motion of the coils before the magnetic poles produces currents in the coils. There are arrangements to make these currents flow properly along the wires outside. Every hospital contains a magneto-electric machine in a box. The patient is asked to hold the brass tubes in his hands which are already connected with the wires leading from the machine, and the handle is turned. The currents are produced and pass through his body.

Q. 670.—(*a*) What are the chief properties of a magnet. (*b*) How can you make a very strong one? (*c*) A wire through which a strong current of electricity is passing is placed above a magnet at right angles to it; what effect will it produce? —M.U., 1888.

Ans.—(1) (*a*) When freely suspended, it places itself in the line joining north and south. (2) When rubbed over a steel piece it imparts magnetism to it. (3) It attracts iron. (*b*) By placing a piece of steel in an insulated coil of wire and passing a current of electricity through the wire a strong magnet can be made. (*c*) The magnet will not be deflected. If the current passes west to east the north-seeking pole will be depressed; but if the current flows east to west, the northern-seeking pole will turn round and point to the south.

Q. 671.—What are electric bells? Describe how an electro-magnet acts in the working of an electric bell.—Lon. Mat., 1902.

Ans.—Electric bell is a contrivance by means of which a continuous alarm may be produced at the place required. These bells are, therefore,

used to serve as signals to call the attention of others. The important part of an electric bell consists of an electro-magnet which attracts a piece of iron attached to a spring. When this piece of iron is attracted by the electro-magnet, it makes a hammer strike against a bell (K. fig. 100) placed in a fixed position. When the current ceases to flow through the electro-magnet the hammer connected with the piece of iron will spring back.

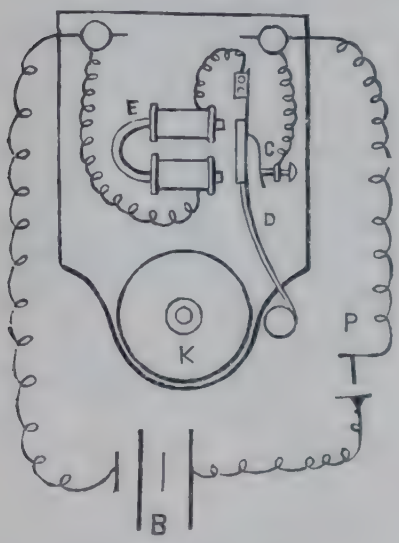

Fig. 100.

The person who wants to send a signal has an arrangement by which he can send a current at will through the electro-magnet. Then the electro-magnet attracts the piece of iron which makes the hammer strike against the bell, but as the piece of iron is moved away from its place, a break is produced in the circuit at o, and the current ceases to flow. The electro-magnet no more acts as such and hence the piece of iron springs back. When it goes back to its former place there is no break and hence the current flows. Once more the piece of iron is attracted by the electro-magnet and the hammer strikes against the bell. In this way a series of sounds can be produced.

Q. 672.—What is a compass-needle, and what is it much used for in connection with electric currents?—M.U., 1894.

Ans.—A compass-needle is a magnetized needle of steel mounted on a pivot. (1) It is used to know the presence of an electric current in a wire, and also its direction and strength. (2) It is used to send signals to distant places.

Q. 673.—State two properties of magnets and their practical applications.

Ans.—(1) A magnet, when freely suspended, points to north and south. On account of this property magnets are used in the construction of mariner's compasses.

(2) Another important property of magnets is that electric currents may be obtained from magnets by moving closed conducting circuits in

their neighbourhood. This property of magnets is made use of in the construction of the magneto-electric machine.

Q. 674.—Give diagrams of two different arrangements for producing signals at a distance by means of the electric current; and explain each arrangement.—M.U., 1896.

Ans.—(1) Have an incandescent lamp at the place to which a signal is to be sent. Connect the wires outside with the poles of a battery at the place from which the signal is to be sent. Make an arrangement by which you can send the current at will. When you send the current the lamp gives light at the place where it is placed and that may be considered to be the signal for any action—(See fig. 101).

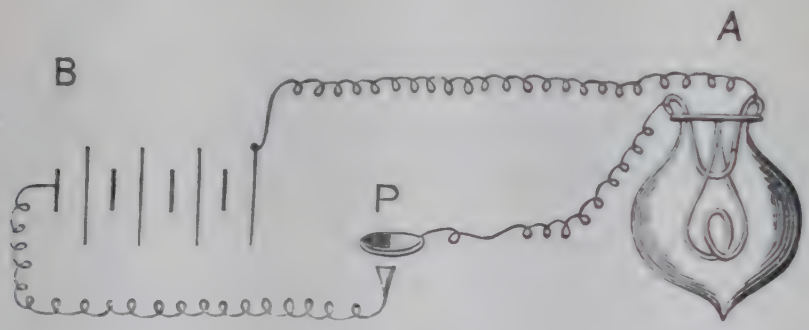

Fig. 101.

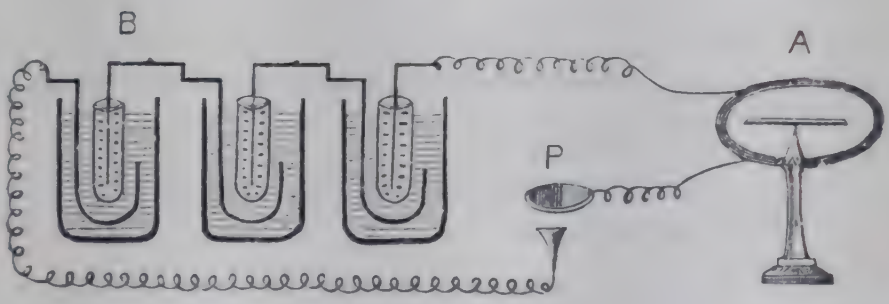

Fig. 102.

(2) Enclose a freely suspended magnetic-needle in an insulated coil of wire and keep it in the place to which the signal is to be sent. Connect the ends of the coil with the poles of a battery at the place from which the signal is to be sent. Make an arrangement so that we may send the current at will. In this way we may send a signal whenever we want by completing the circuit and thus making the magnetic-needle at the other station move.—(See fig. 102).

Q. 675.—Iron filings are dropped along a magnet. Describe the appearance which the magnet presents when taken out and account for it.

Ans. The magnet presents the appearance shown in fig. 103. Iron filings stick to it in large numbers at the ends. In the middle, filings will not be seen. The reason is that only the poles of a magnet possess the power of attracting iron. The power of attraction is absent in the middle.

Fig. 103.

Q. 676.—Given some insulated copper wire, a voltaic battery and a steel needle, how would you show in a general way the principle of the electric telegraph. —M.U., 1890.

Ans. Make a coil of the insulated wire; and place this steel needle in the coil and then pass a current through the wire. The steel needle becomes a magnet. Now suspend this steel needle freely. It remains in the line joining north and south. Connect the poles of the battery by the insulated wire and hold the wire below the suspended needle. The needle will be seen to change its position and be deflected. Take away the wire from below, and the needle goes back to its usual position. These movements of the needle may be used for communication. (See fig. 102.) **If you press P the needle at A is deflected.**

Q. 677.—What is electricity? State what views scientists have held about the nature of electricity from time to time.

Ans. One philosopher, *Symmer*, said that the electrical phenomena were due to two different *electrical* fluids of opposite kinds which neutralize each another when combined; that every substance contained these two fluids combined in equal quantities; that when their condition in a body was disturbed by friction, they gave rise to the phenomena of electricity. Another philosopher, *Franklin*, said that all the electrical phenomena were the result of *an electric fluid* existing in bodies; that so long as this fluid was uniformly distributed in bodies, no change of any kind would be seen; that when these bodies were rubbed or dealt with otherwise, the fluid would distribute itself unequally between the rubber and the thing

rubbed, and then these two things would give rise to different kinds of electricity; the phenomena observed in the body possessing an excess of the fluid were said to be due to positive electricity and the phenomena in the body having a less quantity of the fluid were said to be due to negative electricity. Whatever may be the real nature of electricity, *these theories are at present held not to be correct and true.* It is now believed that electrical phenomena are due to some peculiar conditions which the molecules of bodies assume when rubbed or the ether round the molecules assumes. There are eminent philosophers who suppose that electricity is identical with ether itself. From what we have learnt of it we may say that "Electricity is a powerful physical agent which manifests itself, mainly by attractions, repulsions, by luminous and heating effects, by violent shocks, by chemical decompositions and many other phenomena."

UNANSWERED QUESTIONS.

Q. 678.—State the two laws of the reflection of light.—M.U., 1884; 1889; 1903. If a ray of light falls perpendicularly on a polished surface, how will it be reflected?—M.U., 1889.

Q. 679.—Show by a figure the position of the image of a bright point held in front of a plane mirror.—M.U., 1891.

Q. 680.—Give a sketch to show why the image of a candle flame appears as far behind the mirror as it really is in front of it.—M.U., 1884.

Q. 681.—State the laws of the deviation of light when passing from any medium to one of different optical density.—L.U., 1899 June.

Q. 682.—What is an inverted image? If the capital letter F were drawn on paper and held in front of a mirror, how would you have to draw the letter on the paper, and how hold the paper in order that the image of the letter in the mirror should present its ordinary aspect? —L.U., 1900 Jan.

Q. 683.—A plumbline is held over a mirror; explain with the aid of a diagram the appearance of its image when the mirror is inclined at an angle of 45° to the vertical.—M.U., 1893.

Q. 684.—Describe any method for the determination of the velocity of light, from the observations of celestial phenomena.—B.U., 1898.

Q. 685.—If the sun should be extinguished suddenly, we shall know it only 8 minutes afterwards. Why should this be so?

Q. 686.—What is the difference between a planet and a satellite. How was the velocity of light determined by Romer?

Q. 687.—Explain the terms: mirror, image, normal, angle of incidence, real image, angle of reflection and virtual image.

Q. 688.—Prove geometrically that the reflected rays of a point from a plane mirror *must meet* when produced.

Q. 689.—Explain as clearly as you can how Rœmer determined the velocity of light.—Pun. Ent., 1903.

Q. 690.—What relation, as regards size, shape, position, etc., does an image formed by means of a plane reflecting surface bear to the original object? How does this relation follow from the laws of reflection of light? —Pun. Ent., 1904.

Q. 691.—Explain by aid of a diagram how a person can see a complete image of himself in a plane mirror half of his height.—Pun. Ent., 1902.

Q. 692.—Describe an experiment to show that different colours are differently refrangible.—All. Un., 1902.

Q. 693.—Explain with the help of diagrams what different kinds of images can be formed by means of a camera lens.—Pun. Ent., 1902.

Q. 694.—Show by means of a neat diagram the path of the rays which form the image of an object placed before an ordinary looking-glass. In what respects will the image differ from the object and how far behind the mirror will the object be?—Pun. Ent., 1900.

Q. 695.—Why do objects appear coloured when viewed through a prism of glass? Illustrate your answer by reference to experiments.—Pun. Ent., 1900.

Q. 696.—Distinguish between real image and virtual image, as they are produced by a concave mirror.—B.U., 1900.

Q. 697.—Show how a convex lens can be used as a magnifier.—Cal. U., 1902.

Q. 698.—The image of an object appears as far from a mirror as the object is before the mirror. Is this a law of reflection? What is it? Give reasons.

Q. 699. State and account for the different names by which a concave mirror is known.

Q. 700.—Describe the part played by the reflectors in kerosine and other lamps.

Q. 701. Show by two diagrams how a beam of sunlight is bent in passing (1) through a thick flat plate of glass, (2) through a glass prism.—M.U., 1884.

Q. 702.—A coin at the bottom of an empty jar is hidden from an observer by the side of the jar. But when water is poured into the vessel, it becomes visible. Explain this by a sketch.—M.U., 1889.

Q. 703.—Show by a sketch how a ray of sunlight is bent by a prism, and explain the reason of the rainbow colours produced at the same time. —M.U., 1887.

Q. 704.—Describe what is seen when a slit through which sun light is allowed to pass is looked at through a prism, and draw a diagram showing the path of light from this slit through the prism, to the eye? —M.U., 1897.

Q. 705.—A penny is put at the bottom of a tumbler and water is poured to a depth of 4 inches; when you look down on the penny it looks about 3 inches below the surface. How do you explain this?—L.U., 1903.

Q. 706.—How would you prove that white light is a mixture of light of various colours, and that the constituents of the light could be recombined to produce white light.—B.U., 1898; L.U., 1901.

Q. 707.—If you dip your fingers vertically into water, they appear to be shorter than they really are: explain this.—M.U., 1901.

Q. 708.—Explain with the aid of a diagram how you would find out whether a ray of light consists of one or more colours.—M.U., 1902.

Q. 709.—(*a*) A prism is placed, with its base up and edge down, behind a horizontal slit in the door of a dark room through which the sunlight is passing: show by a figure the arrangement of the spectral colours on a screen in the dark room. (*b*) What is the reason of this decomposition of white light into colours?—M.U., 1894.

Q. 710.—Describe a simple telescope and explain the use of each part.—M.U., 1899; 1901.

Q. 711.—How would you experimentally find the focus a magnifying glass?—M.U., 1890.

Q. 712.—Explain the use of the two lenses in a telescope.

Q. 713.—Explain the difference between deviation and dispersion, and state what you will do to know if a light is elementary or compound.

Q. 714.—What happens to the light of the sun passing successively through three similar glass prisms placed similarly?

Q. 715.—Describe the construction of an electro-magnet and mention some practical applications of it.—B.U., 1897.

Q. 716.—Give an example of (1) the chemical, (2) the heating and (3) lighting effect of electric current.—B.U., 1897.

Q. 717.—Explain how it is that we can see the sun before it gets above the horizon.—Pun. Ent., 1900.

Q. 718.—(*a*) Explain by means of a diagram the fact that a fish in a river does not appear to a person upon the bank to be in the direction in which it actually is. (*b*) Show also the direction in which the person would appear as seen by the fish.—Lon. Mat., 1902 September.

Q. 719.—What is a lens? Compare and contrast its power of forming images with that of (i) a concave mirror and (ii) a convex mirror.

Q. 720.—A double convex lens is placed on the letter of a book and is gradually raised towards the eye. State and account for the effects produced as it approaches the eyes.

Q. 721.—What is photography? What is a negative? Give some examples to show that sun's light has chemical properties.

Q. 722.—How do green substances look through a red glass? Account for your answer.

Q. 723.—Things appear raised and fringed with different colours when looked at through a glass prism during the day. Account (i) for the raised appearance of the object; (ii) for its being fringed with colours; (iii) for the particular order in which those colours are seen over the object.

Q. 724.—Some coloured things cannot be seen in their proper colour in a candle or kerosine light. Account for this.

Q. 725.—A ray of light passes from a luminous point to an observer's eye obliquely through a sheet of glass. Trace its course more especially through the glass.—L.U., 1903 June.

Q. 726.—Two pith balls are suspended by silk thread; the first is touched with excited glass and the second with excited sealing-wax. If the balls are now placed near together, how will they be effected? Explain your auswer fully.—M.U., 1889.

Q. 727.—A Gold-leaf Electroscope is charged with negative electricity and a glass rod rubbed with silk is brought near it. What will take place?—M.U., 1888.

Q. 728.—Describe the Gold-leaf Electroscope, and explain how it may be charged positively by means of a negatively electrified body.—M.U., 1898.

Q. 729.—Describe briefly the Leyden jar. How is it charged? How may it be used to give several persons a shock at the same moment?—M.U., 1884.

Q. 730.—Describe the battery first made by Volta? Given such a battery, a piece of iron and some wire, how would you make a magnet?—M.U., 1886.

Q. 731.—Describe a method for obtaining a steady current of electricity.—M.U., 1898.

Q. 732.—Describe Grove's battery. Explain how it may be used for decomposing water.—M.U., 1889.

Q. 733.—Why is Grove's battery superior to the original Voltaic battery?—M.U., 1884.

Q. 734.—What is the use of (1) Nitric acid in a Grove's battery? (2) Amalgamating the zinc?—M.U., 1893.

Q. 735.—Describe an apparatus by which signals can be sent along a wire to a distant station: explain the principle on which it acts?—M.U., 1885.

Q. 736.—(*a*) You are given a steel needle. How would you ascertain whether it is charged? (*b*) How would you use a magnetic needle to ascertain whether a current of electricity is passing through a straight wire?—M.U., 1899 R: 1894.

Q. 737.—Electricity on a rubbed glass-rod is positive. Is this statement correct? Account for your answer and write it correctly.

Q. 738.—In what respects does an electrified body differ from a body which is not electrified?

Q. 739.—Two pith balls are suspended by wires from an insulated metallic knob. What happens when the knob is touched by an excited glass-rod?

Q. 740.—Describe clearly the action of the spikes on the prime conductor of an electric machine.—Lon. Mat., Sept. 1902.

Q. 741.—A certain substance becomes electrified when it is rubbed with a silk handkerchief. How would you proceed to determine whether it is positively or negatively electrified?—Pun. Ent., 1902.

Q. 742.—What is meant by electrical induction? An excited resin rod is brought near an uncharged Gold-leaf Electroscope and the leaves

are observed to diverge. Explain why the leaves diverge and what kind of electricity is contained by the leaves ?—Pun. Ent., 1900.

Q. 743.—Describe a Gold-leaf Electroscope and explain clearly why the leaves diverge when a charged body is brought near to the instrument without touching it.—Lon. Mat., 1902 Sept.

Q. 744.—Describe an experiment to show that when a sealing wax rod is rubbed with a piece of flannel, both the bodies are electrified. How would you prove that electricity does not spread itself on any of those two bodies ?—Pun. Ent., 1903.

Q. 745.—Describe an experiment which shows that when a Leyden jar is charged, the electrification resides in the glass and not on the metal coatings.—Pun. Ent., 1903.

Q. 746. Describe the construction and explain the action of Gold-leaf Electroscope. I want to know (1) whether a body is or is not charged with electricity. (2) With what kind of electricity it is charged. How should I proceed ?—Pun. Ent., 1904.

Q. 747.—What is meant by *electrical induction*. Give two experimental illustrations of it.—Pun. Ent., 1901.

Q. 748.—Describe two experiments by which you could prove that *frictional* electricity resides on the surface. Pun. Ent., 1901.

Q. 749.—Many Gold-leaf Electroscopes are made with a point projecting from the metal plate above the gold leaves ? For what purposes is this done ?—Pun. Ent., 1901,

Q. 750.—What is a condenser ? Why is it so called ? On what does the charge depend ? Describe a form of condenser in common use. —Cal. Un., 1904.

Q. 751.—A Leyden jar is held by the knob, and the outer coating is presented to the prime conductor of a machine from which it receives a charge. If the jar is placed on the table, the operator receives a shock. Explain these and show how he could ultimately get the jar placed on the table without discharging it.—Lon. Mat., 1902 June.

Q. 752.—Explain the process of charging a body by induction.

Q. 753.—Explain clearly why a pith ball rushes to an excited glass rod.

Q. 754.—Describe a pith ball electroscope. By what other name is it known ?

Q. 755.—How would you proceed to determine the charge on a given body by means of a Gold-leaf Electroscope, charging the instrument by induction.

Q. 756.—How would you prove that there is no electrification within a closed conductor which is charged?

Q. 757.—"The prime conductors of electric machines must be completely free from points of any kind and must have a spherical shape as complete as possible." Explain the reason for these precautions.

Q. 758.—You stand on a stool with glass legs touching the prime conductor of an electric machine. The machine is then worked, but you do not see sparks. Account for this.

Q. 759.—If another person standing on the earth touches you (Q. 758) what happens?

Q. 760. A Gold-leaf Electroscope has a sharp point attached to its cap, and a positively charged ball is held over the point for a short time and then withdrawn. Describe and explain the successive indications of the electroscope.—B.U., 1898.

Q. 761.—If in the working of the plate electric machine the rubbers are not connected with the earth, how will the working of the instrument be affected?

Q. 762.—State the conditions necessary to produce an electric spark.

Q. 763.—Explain the action of a lightning conductor. Why is it not accurate to say that a lightning conductor *silently draws off* the electricity in the clouds?

Q. 764.—A pointed rod is held in the hand and presented to a charged conductor. Explain what happens. Will there be any difference in the effect produced, if the conductor be provided with the point before being charged?

Q. 765.—Explain what is meant by polarization in a simple Volta's cell and describe any form of cell in which it is avoided.—L.U., 1903.

Q. 766.—Describe a Grove's cell. Explain the purpose of its component parts. By the help of an equation, or in words state the chemical action in the cell. What is the use of amalgamating the zinc and how is it done?—B.U., 1898.

Q. 767.—What kinds of Leyden jars accumulate the greatest quantities of electricity?

Q. 768.—What is a cell? State and explain what happens in the following cases:—(1) a piece of commercial zinc is put into sulphuric acid, (2) a piece of pure zinc is put into sulphuric acid, and (3) a copper wire is made to touch the piece of pure zinc in (2).

Q. 769.—Describe a Volta cell, and explain how an electric current is produced by it. Define positive pole, positive plate, polarization, and internal resistance.

Q. 770.—What apparatus would you use and how would you arrange it to decompose water by an electric current? Give a carefully drawn diagram.—Lon. Mat., 1903.

Q. 771.—Sketch Grove's battery and describe its action. Mention any precaution that you would take in preparing this battery for action. How would you 'amalgamate' the zinc plates?—Pun. Ent., 1902 : 1903.

Q. 772.—How would you expect a magnetic needle resting on a pivot to behave towards an electrical current passing in its neighbourhood?—Pun. Ent., 1902.

Q. 773.—What is meant by a constant battery? Describe any one form of the constant cell, and point out the advantages it possesses over the ordinary Volta's cell.—Pun. Ent., 1900.

Q. 774.—In what way would you determine whether an electric current was flowing in a wire or not? If you found a current in the wire how could you tell which end was connected with the platinum plate in the battery, supposing a Grove's cell was being used.—Pun. Un., 1900.

Q. 775.—A Grove's battery was filled by mistake with dilute sulphuric acid in both the porous cell and the outer vessel. What would be the effect on the resulting current, and what is the cause of this effect?—M. U., 1904.

Q. 776.—Into an insulated uncharged metal jar standing on the cap of an electroscope, an electrified brass ball is lowered without contact; the jar is then touched for a moment with the finger, and the ball is next allowed to touch the jar, after which it is removed. Find the various effects produced on the gold leaves during the course of the experiment.

Q. 777.—A strong electric current is sent in succession through a thin iron wire, a cell containing dilute sulphuric acid with platinum electrodes, and a cell containing a solution of sulphate of copper with copper electrodes. What will happen in each case?—Lon. Mat., 1903.

Q. 778.—How does a magnetic needle, resting on a point, behave when brought near to a long straight wire through which a current of electricity is flowing? How is the effect produced by the current on the needle made practical use of?—M.U., 1898.

Q. 779.—Describe four ways in which a signal may be sent to a distance by means of a current of electricity.—M.U., 1903.

Q. 780.—State carefully how you would proceed to prove with the help of the electroscope that there are two kinds of electricity. Explain your method.—B.U., 1899.

Q. 781.—Describe any two methods by which you could magnetise a needle so that the point shall be a south-seeking pole.—L.U., 1903.

Q. 782.—Two steel needles are magnetised so that the eye of each is a north-seeking pole. The needles are stuck by their points into separate bits of cork, so that when thrown into water they float upright with the eyes downwards. How will they behave towards each other floating in this way?

Q. 783.—Describe an experiment to show that when an insulated conductor is electrified by induction, two opposite charges are induced on it, that which is further from the inducing charge being of the same kind.—L.U., 1896.

Q. 784.—Describe an experiment to prove that the charge on an electrified conductor lies wholly on the surface.—L.U., 1877.

Q. 785.—The top of an electroscope is coated with sealing wax, which is rubbed by flannel held in an insulating suport. Describe and explain the behaviour of the leaves (1) while the rubbing is in progress, (2) when the flannel is removed.

Q. 786.—Describe how to make and how to use an electric (electrostatic) condenser.—L.U., 1898.

Q. 787.—A plate of pure zinc and a plate of copper are dipped into dilute sulphuric acid and then connected by copper wire. What changes take place in the plates, wire and acid when the circuit is complete.—L.U., 1890.

Q. 788.—Describe the Leyden jar, and explain its use. Why is it called a condenser? What is the best method of discharging it. What is the residual charge and how is it explained.—B.U., 1900.

Q. 789.—Describe the construction and the working of the plate electric machine—B.U., 1899.

Q. 790.—Mention two liquids which conduct electricity without undergoing decomposition, two which conduct, and are thereby decomposed, two which do not conduct at all.—L.U., 1901.

Q. 791.—A steel wire is suspended by a thread and balanced horizontally. It is next magnetized. Describe its behaviour and explain fully —B.U., 1899.

Q. 792.—Describe the various parts of a complete electric bell circuit, and explain how the current causes the bell to ring.—L.U., 1902.

Q. 793.—Explain the action of two magnets upon each other.—B.U., 1900.

Q. 794.—How will you make a permanent magnet and what material would you employ for the purpose? What is the effect of heating a magnet? If you break a bar magnet into two, how will the piece behave? —B.U., 1898.

HOE AND CO., MADRAS.

Part II.

Chemistry.

SECTION I.

Elements, Compounds, Air, Water, &c.

Q. 795. How do you account for such a great variety of things in the world when the number of elements is only about eighty?

Ans. (1) These elements combine with one another and give rise to entirely different compounds.

(2) The same elements combine in different proportions and produce different compounds.

(3) In some cases, bodies having the same chemical composition possess entirely different physical properties, as chalk and marble.

For these three reasons, the variety of things is very great although the number of elements giving rise to them is limited.

Q. 796. Distinguish between a mechanical mixture and a chemical combination.—M. U. 1884.

Ans.

Mechanical Mixture (or, Mixture).	Chemical Compound (or, Compound).
1. In a mixture the properties of the resulting substance are those of the ingredients.	1. In a compound the properties of the resulting substances are entirely different from those of the ingredients.
2. In almost all cases, no heat or light is produced when a mixture is formed.	2. Heat, and sometimes light, are produced, when a compound is formed.
3. No proportion of things is necessary to make a mixture.	3. When a compound is formed, the things that produce it enter into combination in a definite proportion.
4. No heat is necessary to produce a mixture.	4. In most cases, chemical action must be started.
5. The constituents of a mixture can be separated by mechanical means, such as filtering, evaporation, etc.	5. The constituents of a compound cannot be separated by mechanical means.

Q. 797. Classify the following substances into el mentary and compound bodies:—Carbonic acid, chlorin chalk, chlorate of potash, common salt, silicon, mercur saltpetre, ammonia, sodium, galena, quartz, silica. Mentio the elements of which the compounds consist.— M. U. 1882.

Ans.

Elements.	Compounds and their Components.	
Chlorine.	Carbonic acid gas ...	Carbon and oxygen.
Mercury.	Chalk ...	Calcium, carbon and oxygen.
Silicon.	Chlorate of potash ..	Potassium, chlorine and oxyge
Sodium.	Common salt ...	Sodium and chlorine.
	Silica ...	Silicon and oxygen.
	Galena ...	Lead and sulphur.
	Quartz ...	Silicon and oxygen
	Ammonia ...	Hydrogen and nitrogen.
	Saltpetre ..	Potassium, Nitrogen, and oxyg

Q. 798. Explain the term 'constituents' and descri experiments to show—

(1) that a mixture has the properties of its constitue while a compound has entirely different prop ties;

(2) that the constituents of a mixture can be eas separated while the components of a compound c not be so separated.

Ans. By the term 'constituents' or 'components' is unde the simple that form the given body. Water is composed of oxy and hydrogen. Hence, oxygen and hydrogen are the constituent water.

(1) Take some finely powdered sulphur, and also finely powdered iron. Mix these together. The resulting substance possesses the colour of sulphur as well as of iron, so that it looks grey. If the two are made to combine, a chemical compound called *Iron sulphide* is formed, and it is black.

(2) Magnets attract iron. Therefore, if a magnet is introduced into a mixture of iron and sulphur, the iron particles attach themselves to the magnet and can be separated from the sulphur particles. But a magnet cannot separate the particles of iron from the compound, iron sulphide.

Q. 799. How do we know (1) that the composition of chalk is quicklime and carbonic acid; and (2) that it is a compound and not a mixture of these constituents?—M. U. 1902.

Ans. (1) Burn chalk. Carbon dioxide escapes and quicklime is left behind.

(2) When water is poured on quicklime, great heat is given off and slaked lime is formed. But when water is poured on chalk, no such phenomena are observed. Carbon dioxide is a gas that does not allow a candle to burn in it. Chalk is a solid. Thus, we see that though the components of chalk are quicklime and carbonic acid gas, the substance is entirely different from either of these. Moreover, when a certain definite quantity of chalk is decomposed, it always gives us the same quantities of quicklime and carbonic acid gas. Hence, chalk is a compound and not a mixture.

Q. 800. State why air is considered to be a *Mechanical Mixture* of Oxygen and Nitrogen and not a *Chemical Compound* between these elements.—M. U. 1891.

Ans. (1) When a compound is formed, heat or light is produced. But by mixing oxygen and nitrogen in the proportion in which they are found in the air, no heat or light is produced and the mixture behaves in all respects like the air. Therefore, the air is not a compound.

(2) The components of a chemical compound have always the same proportion. But the components of air vary slightly in their proportion in different parts of the world. Therefore, the air is not a compound.

(3) When a compound dissolves in water, it does not change its composition. But when air dissolves in water, it changes its composition ; the dissolved air is found to contain more oxygen than nitrogen on account of the fact that oxygen dissolves more than nitrogen. Sugar is a compound, and it never changes its composition when dissolving in water.

(4) "Gases combine in the ratio of their atomic weights or in multiples of these ; the ratio between oxygen and nitrogen in the air is not that of the combining weights of oxygen and nitrogen, or in multiples thereof."

Q. 801. Classify the following substances under the heads (1) elements (2) chemical compounds or (3) mechanical mixtures, and in each case give the reasons for your classification :—Coal gas, Sea water, Brimstone, White lead, Quicksilver, Black lead and Quicklime.—M. U. 1886.

Ans. ELEMENTS : *Brimstone, Black lead, and Quicksilver.* These are all elements. For these cannot be split up into simpler forms. Brimstone is the ordinary roll sulphur. Black lead is a form of carbon. Quicksilver is another name for mercury.

COMPOUNDS : *White lead* ($Pb\ CO_3$) *and Quicklime* (CaO). These are compounds, for they are formed by the union of definite quantities of their constituents. Their formulae enable us to ascertain their constituents

MIXTURES : *Coal gas* and *Sea water.* Coal gas is a mixture, because it has in it marsh gas, hydrogen, carbon monoxide, etc. Sea water is a mixture, because it has in it common salt, water, etc., and these can be easily separated from one another.

AIR.

Q 802. How would you ascertain the composition of air ? The respiration of animals is said to be an act of oxidation. Explain the meaning of this statement, name the products formed as a result of this act, and describe how the presence of each in expired air may be proved.—M. U. 1890.

Ans. Take a small china dish and float it on water. Put in that dish a piece of phosphorus. Take a large wide-mouthed bottle, and invert it over the china dish. Fire the phosphorus in the dish before inverting the bottle over it. The phosphorus readily burns, giving out white fumes (Fig 104); after burning for some time, it will be put out, although a little of it may still remain unburnt. After a time the white fumes begin to dissolve in the water below, and as they dissolve, the water begins to rise in the bottle. When all the fumes are dissolved, it will be found that water has filled nearly a fifth part of the bottle (Fig. 105). This tells you that phosphorus, when burning, has consumed a fifth part of the air in the jar.

Fig. 104.

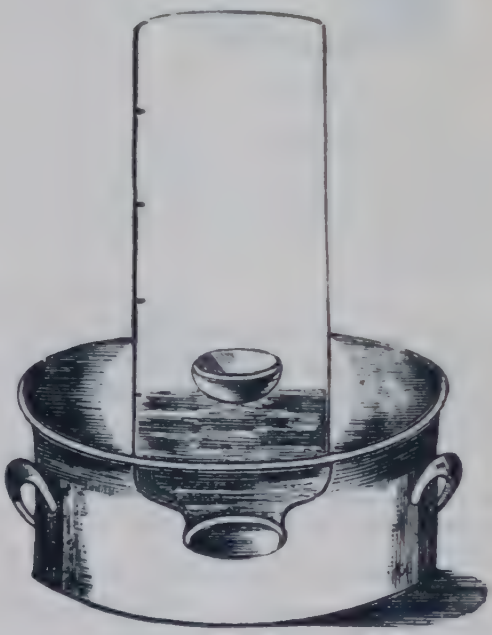

Fig. 105.

Next try to find out the nature of the remaining part of the air in the bottle. To do this, close the mouth of the bottle carefully while under water, and turn it up. Now the water will be at the bottom and the gas, above it. (Fig. 106). Introduce a burning candle into the bottle, and it will be put out at once. The gas does not turn limewater milky.

Thus, you learn that the air in the bottle is composed of two gases one of which allows things to burn in it, while the other does not allow things to burn in it. The gas which allows things to burn in it is called *Oxygen* and constitutes a fifth part of the air; it is this gas that phosphorus has consumed in burning. The other gas which does not allow things to burn in it is called *Nitrogen* and constitutes four-fifths of the air.

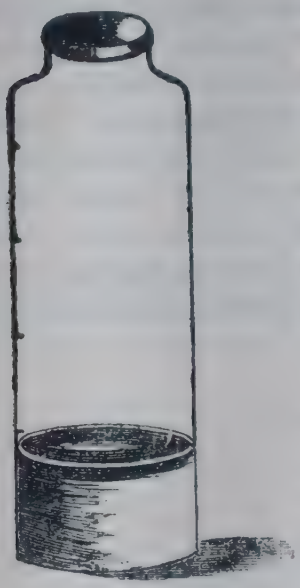

Fig. 106.

What is true of the air in the bottle is true of the air outside. Thus, we learn that the air is composed chiefly of oxygen and nitrogen. The former allows things to burn in it and is nearly $\frac{1}{5}$ of it; the latter does not allow things to burn in it and is nearly $\frac{4}{5}$ of it.

The statement means that when animals breathe in, oxygen combines with the carbon and hydrogen of the body and thus, oxidation goes on in the body during the process of respiration.

Carbon dioxide and steam are produced during the process of respiration.

If you breathe through lime water, it turns milky. The milkiness is due to the formation of calcium carbonate. Lime combines with carbon dioxide and forms calcium carbonate. As lime water contains lime, the carbon dioxide that is necessary must have been taken from the breath.

Breathe on a clean slate for a few minutes. Drops of water will be seen in a short time on the slate. This shows that we produce also steam when we breathe out.

Q. 803. Respiration and combustion are said to be similar processes. What evidence is there to support this statement? In what respect would you expect the air contained in a close room crowded with people to differ from the outside air? By what natural process is the air which has been altered by respiration restored to its original condition?—M. U. 1888.

Ans. In respiration, as well as combustion, heat is produced. In the combustion of a hydrocarbon in air or oxygen, steam and carbon dioxide are produced. In respiration also, these two things are produced.

The outside air does not contain such a large quantity of carbon dioxide as the air in the crowded and closed room; this contains a larger quantity of vapour of water than the outside air.

Carbon dioxide from the air is taken up by the plants and trees. The vegetable world takes up carbon dioxide, decomposes it in sunlight, uses up carbon for its growth and gives up oxygen to the air.

Q. 804. What do we learn about the composition of air by burning phosphorus in a bell-jar over water? Does the water undergo any changes? If so, state how they may be recognised and to what they are due.—M. U. 1893.

Ans. (1) We learn that the air is a mixture, chiefly of four parts of nitrogen and one part of oxygen.

(2) Yes. (i) The water rises in the jar after a time; this is on account of the vacancy caused by the oxygen, which, combining with phosphorus, dissolves in water. (ii) Owing to the solution of the fumes in water, the water acquires an acid reaction. This can be found out by putting into that water a blue litmus paper, which soon turns red.

Q. 805. How would you demonstrate in a simple way that plants inhale carbon dioxide and exhale oxygen? State the facts you learn from that experiment.

Ans. "Take a sprig of any plant having large fleshy leaves, fix it in the lower part of a jar of water, invert over it a funnel, on the neck of which a test tube filled with water is fixed, as in Fig. 107. No change takes place if the light is not strong, but if placed in sunlight for some hours the test tube will be nearly filled with gas. Remove it, and examine the gas by its action on flame: it will show itself to be oxygen."—Bower. Spring water is used in the above experiment as it contains carbon dioxide in solution. [No particular precaution need be taken in our country as we have a bright sun always. We must only see that the whole is not allowed to be in a dark place.] From this experiment we learn (1) that plants cannot decompose carbon dioxide in darkness, (2) that plants require sunlight to decompose carbon dioxide and take up carbon, and (3) plants exhale oxygen.

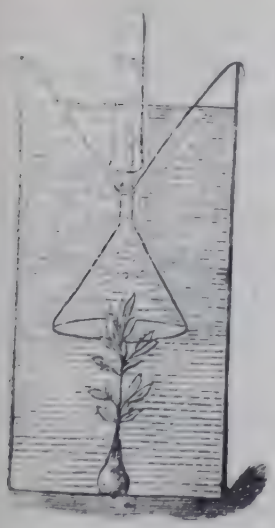

Fig. 107.

Q. 806. "Breathing is said to be an act of oxidation."

(1) How, and where, does this oxidation take place?

(2) Why, then, are not our bodies as hot as the flame of a candle?

Ans. When we breathe in air, it passes down the windpipe (*b*, Fig. 108) into the minute passages of our lungs. Now, impure blood from all parts of the body finds its way into these lungs. Thus on one side of the minute tubes of the lungs (*e*, Fig. 108) we have the blood, and on the other side there is the air which is inhaled. Through the thin walls of the tubes the air passes and acts on the blood. The impurities combine with oxygen, giving rise to carbon doixide and vapour of water. These are exhaled. Thus, breathing is an act of oxidation. The purified blood circulates through the body.

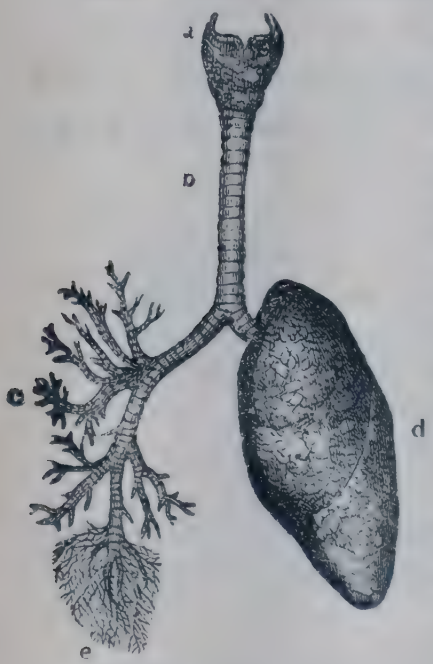

Fig. 108.

(2) Flame also is due to oxidation. But the heat is concentrated in one spot —the flame. In our bodies the heat is spread over the whole body. Consequently the flame is hotter than our bodies.

Q. 807. What changes are produced in the air by the breathing of animals, and during the growth of plants? Describe the experiments in support of your answer.

—Pun. Ent. 1901.

Ans. When animals breathe, they take in the air. This combines with the waste matter of the body, and the compounds formed are exhaled. These compounds are steam and carbon dioxide. Therefore animals, when breathing, diminish the oxygen of the air and add carbon dioxide and watery vapour to the air.

Expt. 1. Breathe through lime water. It becomes milky white. The breath, therefore, contains carbon dioxide.

Expt. 2. Breathe on the cold surface of a school slate or of a glass mirror for some time. Drops of water will be formed. This shows that our breath contains watery vapour.

Plants, during their growth, take in the carbon dioxide of the air, use up carbon to build their stems, &c., and give up oxygen. During the growth of plants, therefore, the air loses its carbon dioxide and gains oxygen.

Expt. 3. Take spring water and arrange the experiment as shown in Fig. 107. Keep the whole in the sunlight for some time. Bubbles of gas will be formed in the test tube. These, on examination, will be found to be oxygen, for they can rekindle a red hot splinter of wood. This shows that the plants have taken up the carbon dioxide *dissolved* in the spring water, and gave up oxygen which collected at the top of the test tube.

Q. 808. Green leaves are placed in two bottles, one of which is filled with fresh spring water and the other with fresh boiled water; both the bottles are then inverted over basins containing respectively spring water and boiled water, and they are placed in sunlight. Bubbles of oxygen gas collect on the leaves in one bottle but not in the other.

(*a*) State in which bottle the bubbles are seen.

(*b*) Give the reason for the difference.

(*c*) Give a chemical test by which this reason may be confirmed.

—M. U. 1904.

Ans:—(*a*) Bubbles are seen in the bottle filled with fresh spring water.

(*b*) Water, when boiled, parts with the gases in solution. So, the boiled water does not possess carbon dioxide. Fresh spring water, on the other hand, has carbon dioxide in solution. This, the leaves decompose, take in carbon for their growth, and give out oxygen which collects in bubbles on the leaves placed in water.

(*c*) i. Add lime water to some fresh spring water. Milkiness is produced, proving that spring water has carbon dioxide in it.

ii. Take some *boiled* water and add lime water to that. No milkiness will be produced, showing that it does not contain carbon dioxide in solution.

Q. 809. State approximately what the difference in composition is between ordinary and 'dissolved air' which has been expelled by boiling from solution in water?

—Lon. Mat. 1899 June.

Ans. Ordinary air contains its chief constituents—oxygen and nitrogen- in the proportion of 1 : 4. The dissolved air contains more of oxygen than nitrogen owing to the fact that oxygen dissolves more in water than nitrogen. The proportion of oxygen to nitrogen in the dissolved air is as 1 : 3 nearly.

Q. 810. Does the air contain any other gases in it besides oxygen and nitrogen? Mention them and describe how their presence may be demonstrated.

Ans. Yes. The air contains vapour of water and a small quantity of carbon dioxide in it besides oxygen and nitrogen.

Take a tumbler and put in it some quantity of ice. In a short time drops of water will be seen outside the tumbler. This is because the air coming into contact with the cold sides of the tumbler gives up its vapour of water, and that is condensed on the outer sides of the tumbler into small drops of water.

Expose a small quantity of lime water to the air. After some time it becomes covered over with a crust. On examination this will be found to be calcium carbonate. Calcium carbonate is formed by the union of carbon dioxide and lime. As lime is contained in the lime water exposed to the air, the carbon dioxide necessary for the formation of calcium carbonate must have been taken from the atmosphere. We learn, therefore, that the air contains carbon dioxide.

Q. 811. How do the properties of pure air differ from those of its components and the properties of steam. from those of its components? How do you account for this difference?—M. U. 1898.

Ans. The Components of the air are chiefly oxygen and nitrogen. The air does not allow things to burn in it as quickly as oxygen. It supports combustion, unlike nitrogen (which does not allow things to burn in it). The air allows things to burn in it. in its own way. This is because the air is a mixture of the two gases. So it partakes of the nature of the two.

Components of steam are hydrogen and oxygen. Steam does not burn even a little- a complete contrast to hydrogen. which burns well nor does it allow things to burn in it. even to a little extent- a striking contrast to oxygen. Thus steam has neither the properties of oxygen, nor of hydrogen- even to a modified extent.

The properties of steam are entirely different from those of its constituents, because it is a chemical compound.

Q. 812. What are the uses of the different constituents of the air?

Ans. (i) *Oxygen.*—(1) This gas is breathed in by animals and enables them to live. (2) It enables fire to burn.

(ii) *Nitrogen.*—This gas moderates the activity of oxygen. If it were not for this gas in the air, things would burn away much more quickly than at present.

(iii) *Vapour of water.*—This helps the formation of clouds, which give us rain. Fog, dew and mist are caused by the vapour of water in the air.

(iv) *Carbon dioxide.*—This gas enables plants and trees to grow. They take in carbon dioxide, utilise carbon for their growth and give up oxygen.

WATER

Q. 813. In what respects does a mixture of oxygen and hydrogen differ from a chemical compound of these bodies?—M. U. 1882.

Ans. (1) In making a mixture of hyrdogen and oxygen, we may take any proportion of the two elements; but if a compound of the two is formed, the two combine in a definite proportion.

(2) The mixture of the two gases partakes of the nature of the two, but the compound of the two entirely differs from either of them.

(3) No heat is produced when a mixture of the two is made, nor is any change of volume observed; but when a compound of the two is formed, heat is produced and a reduction of volume takes place.

Q. 814. (1) What is the composition of water by weight and by volume? (2) By what experiments can the relative proportion of its constituents be demonstrated?

—M. U. 1881; 85. 89; 95.

Ans. The composition of water by volume:—hyd : oxy : : 2 : 1. The composition of water by weight:—hydrogen : oxygen : : 1 : 8

Experiment for determining the composition of water by volume:— Take a funnel. Break off the stem and insert a cork. Through the cork pass two wires of the metal called platinum (see Fig 96). Pour water, to which a little acid is added, into the funnel. Invert two test tubes filled with water over each of the platinum wires in the funnel. Connect the plantinum wires with the poles of a battery. The current can pass through the water in the funnel because it is acidulated. As the current passes, water in both of the tubes will be seen to be displaced by colourless gases. After a time, you will see that in one of the tubes twice as much gas has collected as in the other. As soon as one of the tubes is full of gas, take it out and, keeping it in the same position, apply a lighted match at the mouth—a sharp report will be heard and a pale flame will be seen at the mouth. This gas is hydrogen. Take the other tube which contains gas only to half of it and turn it up. Now the upper half of it contains the gas. Insert a glowing piece of wood into it. It is rekindled. This gas is oxygen. Thus you learn that the composition of water is two parts of hydrogen and one part of oxygen by volume.

Experiment for determining the composition of water by weight.— To do this, the things required are (1) a flask for generating hydrogen. (A, Fig. 109) ; (2) a flask containing strong sulphuric acid to remove the moisture from hydrogen which it may carry with it (marked B in the figure). As sulphuric acid absorbs moisture, hydrogen may be dried by being passed through strong sulphuric acid ; (3) a bulb tube of hard glass (C), the bulb of which contains black oxide of copper, so that the oxygen of it may be made to combine with hydrogen to form water ; (4) a U-shaped tube (D) containing calcium chloride to absorb the water produced by the combination of the hydrogen from the flask in (A) and the oxygen of the copper-oxide in the bulb tube (C). Before proceeding with the experiment, weigh the bulb tube with the black oxide of copper in it. Note down the weight. Then weigh the U-shaped tube with calcium chloride in it. Note down the weight. Then connect the delivery tube of the hydrogen generating flask with the flask containing strong sulphuric acid. Let the hydrogen bubble through the acid. Let there be another tube in the cork of the flask (B) to enable the hydrogen to come out, and connect this tube with the tube (C).

Connect the bulb-tube (C), with the U-shaped tube (D). Now put some zinc clippings into the flask (A) and pour sulphuric acid over that, through the funnel-tube which passes through

the cork right to the bottom Then hydrogen gas will be given out which may be seen to bubble through the liquid in the flask (B). This passes through the tube (C) and thence through the U-shaped tube. So far no change will be seen to have taken place in the copper oxide of the tube (C). Heat the bulb. Then the colour of the black oxide changes to a bright red metallic tint and drops of water will be seen on the sides of the tube. These drops will be carried down to the U-tube and there absorbed by the calcium chloride in it. After the black oxide is changed into red copper, take out the lamp. The chemical change that has taken place is, that copper oxide is decomposed and its oxygen combined with hydrogen forming vapour of water and leaving behind metallic copper. Now weigh the bulb tube again. It will be found to weigh less. This is because the copper-oxide in it has parted with its oxygen. In an experiment once made, this loss of weight was 40 grains. Then weigh the U-shaped tube. It weighs more, having absorbed the water formed by the combination of hydrogen produced in the flask(A) and oxygen in the copper oxide of the tube (C). In the experiment mentioned above, the gain of the U-shaped tube in weight was 45 grains. Therefore, 45 grains of water contain 40grains of oxygen and 5 grains of hydrogen. Therefore, we learn that the proportion of hydrogen to oxygen in water is as 5 : 40 or 1 : 8 by weight.

Q. 815. What quantity of water is represented by the formula $O H_2$?—M. U. 1889.

Ans. A formula always represents one molecule of the substance. Hence the given formula represents a molecule of water.

Q. 816. Make a sketch, occupying a whole sheet of your answer paper, of the apparatus you have seen used to prove the composition of water by passing dry hydrogen over heated copper oxide, and describe how the operation is performed.

From the following results of an experiment calculate the percentage of the composition of water by weight :—

Weight of tube and copper oxide, before experiment .. . .. 67·42 grms.

Weight of tube and copper, after the experiment .. .. .. 66·82 ,,

Weight of tube for absorbing the water formed, before experiment .. .. 55·50 ,,

Weight of same tube, after experiment .. 56·176 ,,

—M. U. 1898.

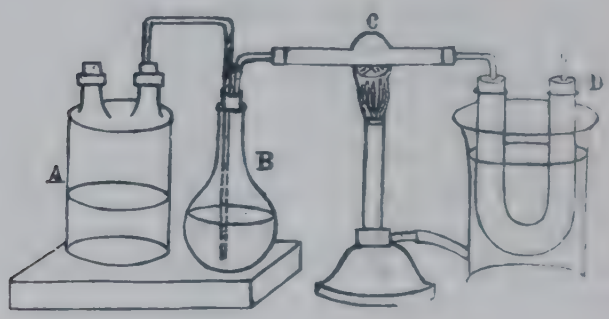

Fig. 109.

Ans.

The oxygen given out by the oxide of copper = 67·42 − 66·82 = 0·60 grm.

The weight of steam formed = 56·176 − 55·50 = 0·676 grm.

Now,

0·676 grms. of water has 0·60 grms. of oxygen

∴ 100 grms. of water $\frac{\cdot 60}{\cdot 676} \times 100 = 88\frac{8}{9}$ grms. of O nearly.

∴ 100 grms. of steam has $100 - 88\frac{8}{9} = 11\frac{1}{9}$ grms. of H.

∴ $88\frac{8}{9}$ per cent. of water by weight oxygen and $11\frac{1}{9}$ per cent. of water by weight is hydrogen.

Q. 817. (*a*) Mention the principal substances that ordinary river water contains in solution.

(*b*) What substances, particularly injurious to health, often occur in river water or shallow well water of towns? Describe some simple process (such as could be used in any

household) by means of which such dangerous waters could be made safer to drink.—M. U. 1886.

Ans. (*a*) Chalk, gypsum, carbon dioxide, rock salt, etc., according to the soil through which the river passes.

(*b*) The greater the number of towns situated on its banks, the greater the impurities which a river carries down its course. Wells in thickly populated cities or very near dwelling and farm-houses also contain similar impurities. These are nitrates, chlorides and nitrites. Moreover, both specimens of water contain suspended impurities.

Means of removing these:—

(i) *Filtration.*—Pass the liquid through a fine porous medium. The suspended impurities are kept back.

(ii) *By Boiling and Cooling.*—This throws down substances in solution, drives out dissolved gases, and kills noxious germs.

(iii) Potassium permanganate crystals may be thrown into wells to destroy the organic impurities.

Q. 818. Give two tests by which distilled water can be distinguished from river or well water. How would you distinguish between hard and soft waters?—M. U. 1896.

Ans. (1) Heat a small quantity of the specimens separately in watch glasses. That which evaporates, leaving no residue, must be taken to be distilled water.

(2) Add lime water to the specimens, separately taking small quantities of them into test tubes. That which produces no milkiness may be taken to be distilled water.

Hard and soft waters may be distinguished by soap-water test. I would take the water in a test tube, shake it with soap solution. If lather is freely produced, it is soft water. If the soap curdles away it is hard water.

Q. 819. Explain how drinkable water can be obtained from sea water.—M. U. 1894.

Ans. The impurities in the sea water can be removed by distillation. The water is poured into a vessel and heated. By a suitable arrangement the steam is condensed.

The water thus produced is perfectly pure and can be used for drinking purposes. Fig. 110 illustrates how distillation is carried on on a large scale, and Fig. 113 illustrates distillation on a small scale.

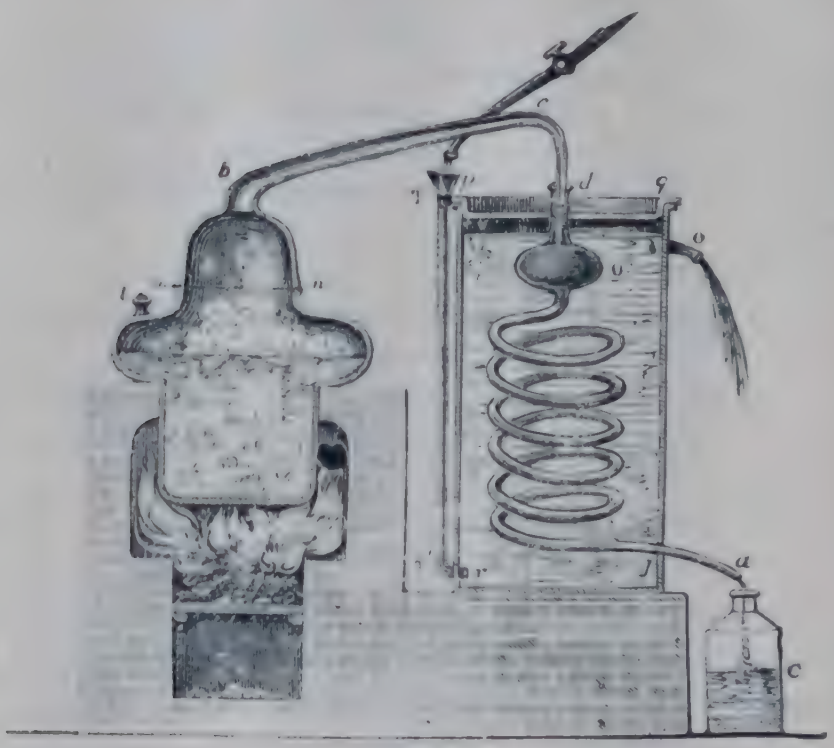

Fig. 110.

Q. 820. (*a*) Without describing any experiments, state the experimental facts and the reasons for expressing the composition of water by the formula H_2O.

(*b*) If 8, instead of 16, is taken as the combining weight of oxygen, what would be the formula for water, and why.

(*c*) 117 grammes of water are formed when hydrogen is passed over a heated oxide; calculate (1) the loss of weight sustained by the oxide; and (2) the weight of the hydrogen converted into water.—M. U. 1904.

Ans. (a) When water is decomposed by electricity, it always yields two volumes of hydrogen and one volumes of oxygen. Since a given quantity of water always yields two volumes of hydrogen and one volume of oxygen, the formula of water has been taken to be H_2O.

(*b*) If the combining weight of oxygen is sixteen, the oxygen present in a molecule of water is denoted by 1; but if the combining weight of oxygen be taken as 8, the oxygen present in a molecule of water will have to be represented by 2, and the formula for water would be $H_2 O_2$.

[The student will do well to note that, in this case, the formula would not faithfully represent the proportion of oxygen and hydrogen by volume.]

(*c*) 117 grms. of water contain 13 grms. of hydrogen and 104 grms. of oxygen.

(1) Since the oxygen must have been taken from the oxide alone, the oxide sustained a loss of 104 grms.

(2) Thirteen grms. of hydrogen were converted into water.

Q. 821. Sea water and rain water are separately (1) mixed with soap solution, (2) mixed with silver nitrate solution, and (3) evaporated. State and explain what happens in each case.—M. U. 1895.

Ans. (1) *The soap solution is seen to curdle with the sea water and no lather is formed.*

Reason.—The substances dissolved in the sea water combine with soap and form insoluble compounds which are seen as such.

Rain water produces lather when shaken with soap.

Reason.—The rain water has no substances which form insoluble compounds with soap. The soap solution, therefore, when shaken with such water produces lather.

(2) *The sea water gives a thick white precipitate with silver nitrate solution, while the rain water does not.*

Reason.—The common salt in the sea water combines with silver nitrate and forms silver chloride, a white insoluble compound This is seen in the liquid. Rain water contains nothing in it that can combine with silver nitrate and produce an insoluble compound.

(3) On evaporation, the sea water leaves behind common salt; the rain water leaves nothing behind.

Q. 822. To a specimen of water, lime water and caustic potash are separately added, and both produce a white precipitate. With another specimen, lime water gives the precipitate, but caustic potash does not. What inference

may be drawn from these observations regarding the substances present in each sample of water?—M. U. 1899.

Ans. The water that produces a white precipitate with caustic potash, as well as lime water, must be taken to be water temporarily hard with chalk.

Reason.—Chalk dissolves in the presence of carbon dioxide and produces hardness. This carbon dioxide, in the above examples, united with caustic potash in the one case, and with lime water in the other case, throwing down the dissolved chalk which appears as a white precipitate.

The other specimen which produces precipitate with lime water, but not with caustic potash, is simply water containing carbon dioxide in it.

Reason.—Lime water combines with the dissolved carbon dioxide and forms calcium carbonate, which is thrown down as white insoluble precipitate. Caustic potash also combines with carbon dioxide and forms potassium carbonate, but it is a soluble salt; therefore, no precipitate is thrown down.

Q. 823. (1) What is sodium amalgam? (2) How is it prepared? (3) What takes place when it is brought into contact with water?—M. U. 1900.

Ans. (1) Sodium amalgam is a mixture of sodium and mercury.

(2) A piece of sodium is put into a mortar and a certain quantity of mercury (usually four times its bulk) is poured over it, and a few strokes of the pestle complete the formation of the amalgam.

(3) Bubbles of hydrogen will be given out and a solution of caustic soda will be formed.

Q. 824. What substances are required to make a solution? How would you proceed to find out whether a given substance dissolves in a liquid or not.

Ans. The substances required to make a solution are (1) a liquid and (2) any substance that can dissolve in that liquid.

To know whether a given substance dissolves in a liquid or not, put a little of that substance into the liquid. If, after sometime, the substance disappears, wholly or partly, leaving the liquid clear as before, we understand that the substance dissolves in the given liquid.

If, however, the substance still remains in the liquid, and we suspect that a small quantity of it may have dissolved in it, take a

little of the liquid and heat it in a dish till all the liquid has evaporated. If nothing is left behind in the dish, we learn that the substance did not dissolve in the liquid and hence, it is an insoluble substance. If a residue is left behind, the inference is that a part of the substance had dissolved in it; so, it is a soluble substance.

Q. 825. Do gases dissolve in water? Give examples. State which of the following can dissolve in water:—Salt, sand, saltpetre, mud, alum, ashes, bluestone, sulphur, sugar and charcoal.

Ans. Gases also dissolve in water. Soda water, lemonade and other aerated waters contain carbon dioxide dissolved in it. Ordinary water contains some air dissolved in it, and it is by breathing the air dissolved in water that fishes and other water-animals live.

Of the substances given, salt, saltpetre, sugar, bluestone and alum dissolve in water; the rest do not.

Q. 826. Describe the processes of Filtration, Decantation and Distillation, and state the uses to which they are put.

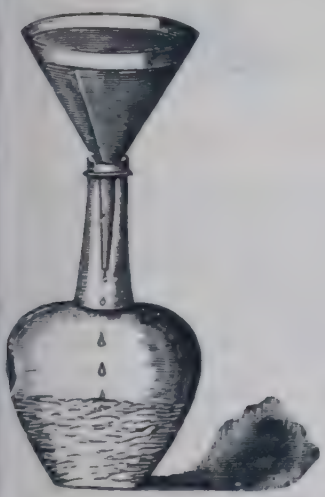

Fig. 111.

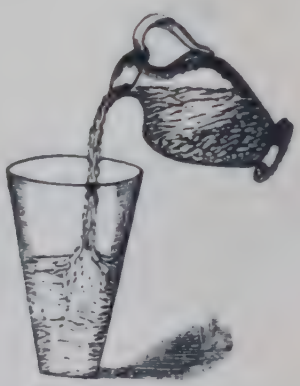

Fig. 112.

Ans. Both 'decantation' and 'filtration' are processes by which the impurities in a liquid that remain undissolved, are removed. Decantation is the process by which the impurities in a liquid are removed, when they settle down at the bottom; in this process the clear liquid above the insoluble matter at the bottom is carefully poured out (Fig 112.) Filtration is the process of removing the undissolved impurities in a liquid, and the process consists in passing the liquid through a porous medium (such as charcoal, blotting paper, or a fine cloth) the pores of which allow the liquid to pass through and keep back the impurities.

Small quantities of liquid may be filtered in the way shown in Fig. 111. Take a filter paper, somewhat like the blotting paper you use, and cut it round. (Fig. 120.) Fold it in the required manner, Figs. 121, 122 and put it in a funnel Fig. 123, and pour the liquid to be filtered into that. The liquid that comes down will be free from suspended impurities.

Distillation is the process in which the liquid to be freed from impurities, is heated till it boils. The vapour that comes out is collected, cooled and condensed (see Figs. 110 and 113). The impurities remain behind in the vessel, while the pure liquid collects in the receiver. Distillation removes the suspended as well as the dissolved impurities from a liquid.

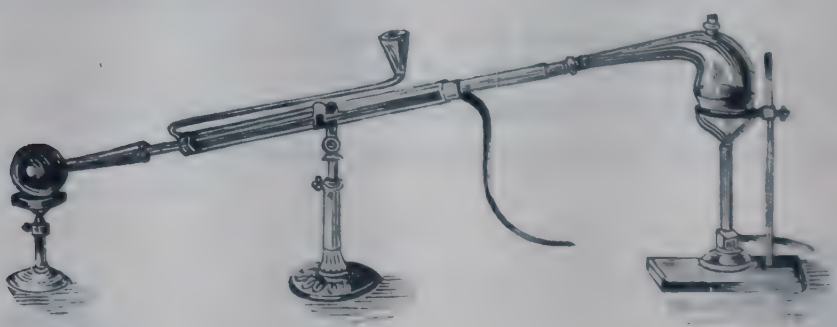

Fig. 113.

In daily life. *Decantation* is of use in washing rice, when the water above it is poured out. *Filtration* is used in removing the suspended impurities in the drinking water, in straining coffee and tea, etc. *Distillation* is used in obtaining pure liquid from a solution; also in the manufacture of such medical waters as omum-water, etc.

Q. 827. What is a saturated solution? Explain why it ceases to be saturated when heated.

Ans. A solution is said to be a saturated solution when it contains so much of the substance in solution that it cannot dissolve more. The power of a liquid to dissolve substances is increased when it is made hotter. Therefore, the same liquid can hold more of the substance in solution at a higher temperature than at a lower temperature. Hence, when a saturated solution is heated, it ceases to be saturated.

Q. 828. Explain the terms (1) Filtrate, (2) Precipitate, (3) Solvent, (4) Crystal.

Ans. (1) Filtrate is the name given to the liquid obtained after passing the liquid through a porous medium whereby the suspended impurities in it are removed.

(2) Precipitate is the name given to the insoluble substance formed in a solution by the addition of another substance to it.

(3) Solvent is the name given to the *liquid* which dissolves a given substance.

(4) Crystals are the regular geometrical solids formed under certain conditions, such as slow evaporation of solutions, or the cooling from its molten state. ; *e.g.*, when the solution of copper sulphate is allowed to evaporate slowly, crystals of copper sulphate are formed.

Q. 829. Describe the process of crystallisation, and draw figures to show the appearance of the crystals of bluestone, alum and washing soda.

Ans. Crystallisation is the process whereby some substances assume fine geometrical shapes under suitable conditions, such as slow evaporation of their solutions, cooling from a molten state &c. Some substances that crystallise when their solutions in water are slowly evaporated are, (1) Bluestone, (Fig 115.) (2) Common salt. (3) Alum, (Fig 114) and (4) Washing Soda. (Fig 116).

Make saturated solutions of alum and bluestone. Allow these to evaporate slowly by exposing them to the air. Within a day or two, small crystals of alum and bluestone will be formed. These crystals will be found to be of different forms. They may be made bigger gradually by attending to them every day and making the necessary changes in their positions.

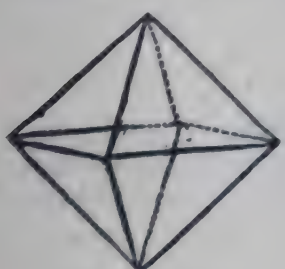

Fig. 114

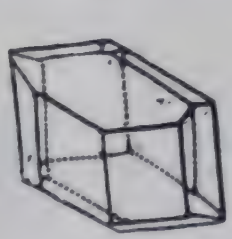

Fig. 115.

Fig. 116.

Q. 830. Hard water is (*a*) boiled, (*b*) mixed with lime water, (*c*) mixed with sodium carbonate. Describe, and explain

exactly, what happens in each of these cases.

—Lon. Mat. 1899 Jan.

Ans. (*a*) If temporarily hard, the carbon dioxide escapes and chalk in solution will be thrown down.

Reason.—Chalk dissolves in water only in the presence of carbon dioxide When the gas is driven away, chalk falls down.

If the water be permanently hard, heating does not affect it.

(*b*) If it be hard chalk water, then milkiness is produced. This is due to the union of lime water with the carbon dioxide in solution. The calcium carbonate formed now, and the chalk formerly held in solution both fall down and cause the milkiness in water. Soon afterwards, the calcium carbonate settles down and the water becomes soft.

(*c*) If hard with gypsum, the water will be turned soft.

Reason.—Sodium carbonate unites with calcium sulphate and forms two things, sodium sulphate which remains in solution, and calcium carbonate which will be thrown down. Sodium sulphate does not render the water hard.

Q. 831. (1) Draw up a list of the more important elements, classifying them into metals and non-metals.

(2) Mention the properties of elements to which the term metallic is applied.

(3) Point out the differences which you have noticed between any oxides of non-metals and those of metals.

—M. U 1902.

Ans.

NON-METALS.		METALS.
(1) Hydrogen, Oxygen, Nitrogen, Chlorine, Fluorine	gases.	Iron, Aluminium, Calcium, Magnesium, Sodium, Potassium, Copper, Zinc, Tin, Mercury, Lead, Silver, and Gold.
Bromine	liquid.	
Carbon, Silicon, Phosphorus, Sulphur	light solids.	

(2) (i) *Solidity.*—All of them are solids, except mercury, which is a liquid.

(ii) *Lustre.*—Metals have a brightness about them (metallic lustre).

(iii) *Specific gravity.*—Metals have a higher specific gravity.

(iv) *Malleability.*—Metals are malleable and ductile.

(v) Metals emit a peculiar characteristic sound when struck.

(vi) *Conductivity.*—Metals are good conductors of heat and electricity.

(3) Oxides of non-metals when dissolved in water impart acid character to the solution. Oxides of metals, when dissolved in water, impart an alkaline character to the solution.

Q. 832. A white powder may be either chalk, alum, or washing soda. How would you identify it without applying chemical tests?—M.U. 1904

Ans. Put it in water, shake it, and keep it for a time. If it does not dissolve in water, then it must be taken to be chalk, for, of the three substances chalk alone is insoluble in water.

If the white powder dissolves, it may be alum, or washing soda. I would pour the solution in a dish and allow it to evaporate slowly keeping it in a place free from disturbance.

I would observe the shape of the crystals formed. If they be octahedral in shape, then I should understand that the given powder was *alum*. Otherwise, washing soda.

Q. 833. What are the advantages in collecting a gas over water? May all gases be collected in that way? (c) Make a sketch of the arrangement for collecting oxygen over water.

Ans. (*a*)(1) We can obtain a pure form of the gas. (2) We shall be able to know how far the jar is filled with the gas. (3) We can fill only the required part of the jar with the gas and leave the remaining part with water. (4) We can know whether the evolution of the gas continues or has stopped.

(*b*) All gases cannot be so collected. Gases that dissolve in water or act chemically upon it, cannot be collected over water.

(*c*) See Fig 118.

SECTION II.

Q. 834. (1). Describe a single experiment by which it can be shown that hydrogen burns with a pale blue flame, and also that it does not support the combustion of a taper.

(2) Make a half-page sketch of the apparatus as seen in actual use during the experiment.—M. U. 1898.

Ans. (1) Into a jar of hydrogen introduce a burning taper. The gas will be seen to burn at the mouth with a pale blue flame; but when the candle is pushed inside the jar, it is put out. See Fig. 117.

Fig. 117.

Q. 835. Describe a *chemical* method of preparing and collecting hydrogen gas from water. What action takes place when the gas is passed over heated black oxide of copper? Describe how the reaction is used for ascertaining the relative weights of hydrogen and oxygen in water.—M. U.

Ans. Into a basin of water put some sodium amalgam. Bubbles of hydrogen from water will be given out. By inverting a jar full of water over the amalgam the gas can be collected. Here sodium combines with the oxygen of the water and liberates hydrogen.

When hydrogen is passed over heated copper oxide steam is formed by the union of hydrogen with the oxygen of the copper oxide and copper is left behind.

For the remaining part of the question, read the answer to Q. 814.

Q. 836. What is meant by oxidation? Give some familiar examples.—M. U. 1884.

Ans. Oxidation is the process of substances combining with oxygen. Firewood burning in the ovens, a candle burning in the air, iron becoming rusty, are familiar examples of oxidation.

Q. 837. If a watch spring were burned in a closed vessel of oxygen, would the weight of the vessel and its contents be

altered by the combustion? Give reasons for your answer? —M. U. 1883.

Ans. The weight of the contents will be the same as before. Oxygen is consumed by the watch spring, which also disappears as such. Both of these remain in the vessel in the form of oxide of iron. So, the weight remains the same as that of the vessel, oxygen, and watch spring before experiment.

Q. 838. (*a*) Describe two different methods of preparing oxygen. (*b*) To which would you assign the preference for (1) cheapness, (2) rapidity with which the gas is evolved, and (3) purity of the gas obtained? —M. U. 1882.

Ans. (i) Heat the red oxide of mercury in the test tube provided with cork and delivery tube. Introduce this delivery tube into a bottle full of water inverted over water in a basin as in Fig. 118. Bubbles of oxygen will displace the water in the bottle and soon fill it.

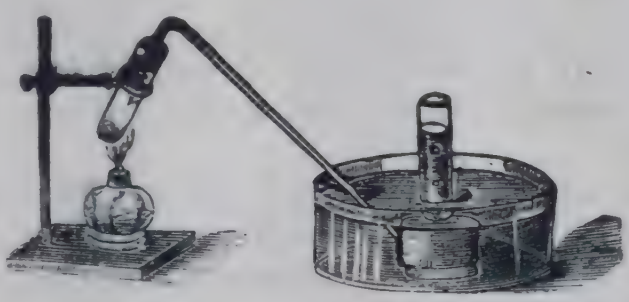

Fig 118.

(ii) In the same way heat a mixture of potassium chlorate and black oxide of manganese. Oxygen will be given out quicker and at a lower temperature.

The first method should be preferred, if purity of the gas is required. The second method should be preferred, if cheapness and the rapidity of the evloution of the gas are required.

Q. 839. A burning jet of hydrogen is placed successively in (1) air, (2) oxygen, (3) hydrogen, and (4) in chlorine. State exactly what occurs in each case.—Pun. Ent. 1901.

Ans. :—(1) The jet continues to burn. The jar of air in which hydrogen has been burnt, contain *steam* and *nitrogen*.

(2) Steam only is formed. The jet continues to burn.

(3) The burning jet ceases to burn, because hydrogen cannc combine with hydrogen.

(4) The jet continues to burn. Hydrochloric acid gas will b formed.

Q. 840. (*a*) Why is it necessary to take care that all th air has been expelled from a hydrogen-generating flask befor igniting the hydrogen collected from it?

(*b*) How is the presence or absence of air in th flask ascertained?—M. U. 1904.

Ans. (*a*) A mixture of hydrogen and air is an explosive mixture Hence, an explosion will take place if a mixture of air and hydroge be set fire to. Consequently, the hydrogen collected must b pure and not a mixture of hydrogen and air. Hence the ai from the flask must be expelled before the gas is collected to b ignited.

(*b*) Invert a test tube over the delivery tube. Hydrogen wi collect in it by upward displacement. Keeping the tube in th same position, light the gas at the mouth. If it burns quietly, th absence of the air may be inferred. If a slight explosion is caused it must be understood that all the air has not been expelled fro the flask.

Q. 841. (1) How is carbonic acid gas prepared? (2) Des cribe an experiment to show that this air exsits in the ai around us. (3) How much carbon would be completely burne by a maund of air? (C = 12, N = 14, O = 16.) —All. U. 1902.

Ans. (1) Carbon dioxide is prepared by the action of hydrochlori acid upon marble (or some other carbonate). Marble is put into bottle provided with a cork and a delivery tube and the acid poured over the marble through a funnel that passes through th cork. The gas that comes out is collected by downward displace ment, for the gas is heavier than the air. (See fig. 119.)

(2) Expose a quantity of lime water in a shallow dish. Afte some time a film of calcium carbonate will be formed on the wate exposed to the air. Calcium carbonate is composed of calciu oxide and carbon dioxide. Calcium oxide is contained in lime wate Carbon dioxide necessary for the formation of calcium carbona must, therefore, have been taken up from the air.

(3) $CO_2 = 12+32 = 44$.

12 maunds of carbon require 32 maunds of oxygen to burn away.

Now, the proportion, by weight, of oxygen and nitrogen in the air is as 23 : 77 nearly.

∴ 100 maunds of air contain 23 maunds of oxygen.

∴ 1 maund of air contains $\frac{23}{100}$ maunds of oxygen.

But 32 maunds of oxygen burn away 12 maunds. of carbon.

∴ $\frac{23}{100}$ maunds..... .. $\frac{12}{32} \times \frac{23}{100}$ = ·09 maunds of carbon.

Q. 842. Describe some experiments with carbonic acid gas and explain clearly what each experiment is meant to show.—Pun. Ent. 1901.

Ans.

Description of the Experiments.	Facts Learnt..
(1) Carbon dioxide is passed into clear lime water ; the lime water turns milky.	(1) When carbon dioxide is passed into lime water, it combines with the lime dissolved in the lime water and forms calcium carbonate, which is a white and insoluble substance. This remains suspended in the liquid and makes it look milky-white.
(2) By passing the gas into lime water for a longer time the liquid becomes clear once more.	(2) Water in which carbon dioxide is dissolved, can hold calcium carbonate in solution. Hence, when carbon dioxide is passed into lime water for a long time the calcium carbonate formed is dissolved by the water and the liquid becomes clear once more.
(3) Two similar big flasks are attached, one to each arm of a balance beam. On passing carbon dioxide into one of the flasks the beam becomes slanting, and the flask with carbon dioxide goes down.	(3) On passing carbon dioxide into the flask it drives out the air in it and occupies its place. As the flask becomes heavier, we learn that carbon dioxide is heavier than the air, bulk for bulk.
(4) A burning candle introduced into a jar of carbon dioxide will not burn.	(4) Carbon dioxide does not allow things to burn in it. *i.e.*, it does not support combustion.

Q. 843 (1) How many compounds does carbon form with oxygen ? (2) What are their names and formulae ? (3) How can they be (*a*) distinguished, (*b*) separated, from each other and (*c*) converted into each other. —Lon. Mat. June. 1901.

Ans. (1) Two compounds, namely, carbon monoxide and carbon dioxide.

(2) Carbon monoxide, formula, CO. Carbon dioxide, formula, CO_2.

(3) (*a*) Introduce a burning taper into the jars containing CO and CO_2. That which takes fire and burns must be taken to be carbon monoxide ; while the other, in which the burning taper is extinguished, must be taken to be carbon dioxide. Or, pour lime water into both jars ; that gas in which the lime water turns milky must be taken to be carbon dioxide, and the other in which the lime water remains clear is carbon monoxide.

(*b*) Into the jar containing the mixture of the two gases pour lime water. This dissolves carbon dioxide and leaves behind carbon monoxide.

(*c*) *Carbon dioxide*, when passed over red-hot charcoal, is converted into carbon monoxide. *Carbon monoxide*, when set fire to, burns forming carbon dioxide.

Q. 844 Explain what happens when 'soda water' is added gradually to some lime water. What do you know of slaked lime ?—Pun. Ent. 1903

Ans. :—The so-called soda water is water having carbon dioxide in solution. Therefore, as the water is added gradually to lime water, it becomes milky owing to the formation of *white, insoluble*, calcium carbonate. Then as more is added, the water becomes once more clear, for, calcium carbonate can dissolve in water in the presence of an excess of carbon dioxide.

Slaked lime : This is obtained by burning limestone and pouring water over it. By burning limestone carbon dioxide escapes and quick lime is left behind. When water is poured over this, great heat is produced and slaked lime is formed. This slaked lime is mixed with sand and is used in the construction of buildings.

Q. 845 (*a*) What experiments would you make in order to demonstrate the presence in coal gas of each of the elements it contains ? (*b*) Describe, as fully as you can, what happens when coal burns in an ordinary fire.—Lon. Mat. 1902.

Ans. (*a*):—(1) I would invert a clean dry tumbler over a burning jet of coal gas. The sides of the tumbler will become dim with steam condensed. This shows that hydrogen must be present in coal gas, which combining with the oxygen of the air has given rise to steam.

(2) I would allow a jet of coal gas to burn in a jar for a short time. When the light is put out, I would pour lime water into the jar. On shaking the jar, the lime water becomes milky, showing that carbon dioxide has been formed when coal gas burnt in the jar. This proves the presence of carbon in coal gas.

(*b*) When coal is burnt in an ordinary fire, the various components of coal combine with oxygen of the air and escape. *Carbon* escapes as carbon dioxide; *hydrogen* escapes as steam; nitrogen escapes as nitrogen; the mineral impurities remain behind in the form of ash. They do not burn away, for at that temperature they cannot burn away. Nitrogen escapes as nitrogen, for it cannot combine with oxygen easily.

Q. 846. Why is it that, while the flame of hydrogen is almost invisible in daylight, coal gas gives out a bright luminous flame?—Pun. Ent. 1904.

Ans.—The light-giving power of a flame depends upon the presence of *incandescent solid* particles in it. Hydrogen flame has no such particles in it and, hence, it is so pale that it cannot be seen in daylight.

Coal gas flame contains incandescent solid particles of carbon and hence, the flame is brighter.

Q. 847. Describe *what is seen* to take place, and name the products formed when,

(*a*) flour of sulphur is heated to boiling with copper turnings;

(*b*) oxide of copper is heated in a bulb tube through which hydrogen is passed;

(*c*) mercury oxide is heated in a test tube;

(*d*) nitric acid is poured on copper turnings;

(*e*) a piece of yellow phosphorus, and a piece of sodium are each placed in a separate dish of water.

—M. U. 1904.

Ans. (*a*) Sulphur unites with copper turnings, *giving rise to a bright glow.* The compound formed is copper sulphide, and remains behind as a black mass.

(*b*) Metallic copper will be left behind, and steam will be formed which condenses later on into water.

(*c*) Metallic mercury is deposited in the upper parts of the tube and makes that part of the tube bright like a mirror. A gas is given out which will be found to be oxygen on examination.

(*d*) Brown fumes, of unwholesome odour, will be given off. A bluish green solution of copper nitrate will be left behind.

Q. 848. How could the metal be separated from each of the following substances, mentioning a different method for each :—(1) lead acetate, (2) hæmatite, (3) copper sulphate, (4) tin stone ? —M. U. 1904.

Ans. (1) *Lead acetae*:—Dissolve it in water and suspend in it a piece of Zinc. Zinc displaces lead from its solution. Lead can thus be separated from the given compound.

(2) *Haematite* :—By heating it strongly with charcoal and limestone in a blast-furnace the metal iron can be obtained from hæmatite.

(3) *Copper Sulphate* :—Heat it to redness. It loses its water of crystallisation and becomes a white powder. Heat it to a higher temperature ; it decomposes and leaves behind copper oxide. Heat this oxide with carbon ; the carbon acts as reducing agent and the metal will be separated.

(4) *Tin stone* :—Powder it and wash it with water so that the impurities may be washed away. Heat the substance strongly with charcoal and the metal will be reduced.

Q. 849. You are given three samples of water, in one of which gypsum is dissolved, in another chalk, and in the third carbonic acid. Explain how you would distinguish between these three waters.—M. U. 1904.

Ans. Small quantities of the three specimens would be taken and lime water added to each of them. In two of them a white precipitate will be produced. These must be taken to be water containing chalk and water containing carbon dioxide, in solution. The reason is that (1) carbon dioxide combines with lime in lime water and forms a white insoluble precipitate ; and (2) chalk

can dissolve only in the presence of carbon dioxide in water. The third specimen which does not produce precipitate with lime water must be gypsum water. This will be confirmed by the addition of a solution of sodium carbonate. Then the two specimens, which have been found to produce a precipitate with lime water, will be heated separately. That which gives a precipitate by mere heating will be taken to be water containing chalk in solution, for by heating, the carbon dioxide is driven out and the dissolved chalk falls down as precipitate. Thus,

The water in which a precipitate is formed only by adding lime water will be,	The water in which a precipitate is formed by boiling as well as by adding lime water will be,	The water in which a precipitate is formed only by the addition of sodium carbonate will be,
Water containing carbon dioxide in solution.	Water containing chalk in solution.	Water cotaining gypsum in solution.

Q. 850 What is tin plate? (1) What advantage does it possess over an iron plate? (3) What is an alloy? (4) Name some common alloys and give the composition of each.

—Pun. Ent. 1903.

Ans. (1) The so-called 'tin plate' is simply an iron plate coated with tin. (2) It possesses the strength of iron and is free from the defect which iron has, namely, of being oxidised when exposed to the air. (3) An alloy is a mixture of two or more metals. (4) Answered (in Sec. III).

Q. 851. How is chlorine prepared, and what are its most important properties?—M. U. 1885.

Ans. By heating a mixture of sodium chloride, sulphuric acid and manganese dioxide, chlorine is given out according to the following equation—

$$2NaCl + 2H_2SO_4 + MnO_2 = Na_2SO_4 + MnSO_4 + 2H_2O + Cl_2.$$

The gas, being heavier than air bulk for bulk, can be collected by downward displacement, Fig 119.

Properties:—(1) It is a gas possessing a greenish yellow colour. (2) It has a most disagreeable and powerfully suffocating smell. (3) It is a gas heavier than the air. (4) It does not support

life and, if inhaled in the pure state, causes death. (5) It dissolves in water to a very great extent. (6) It is not combustible, but supports the combustion of many burning bodies. (7) It is a very active element, because "it acts upon a large number of substances at ordinary temperatures, and in many cases the combination is sufficiently energetic to result in the inflammation of the bodies." (8) Chlorine cannot combine with carbon directly. (9) It has a powerful attraction for hydrogen. (10) It possesses the power of bleaching vegetable matter.

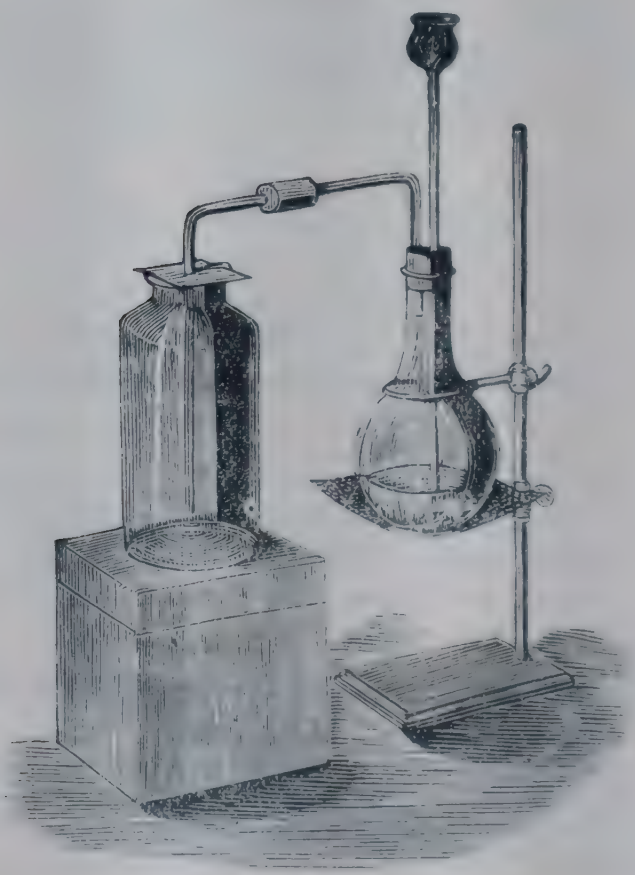

Fig. 119.

Q. 852. Name the gas which is given off when sulphuric acid is heated with common salt and black oxide of manganese; and state how blue litmus paper would be affected by an aqueous solution of the gas.—M. U. 1885.

Ans. The gas given off is chlorine. The blue litmus paper will soon be bleached, *i.e.*, becomes colourless.

Q. 852*a*. Draw figures to show how a small quantity of a liquid may be filtered by means of a filter paper.

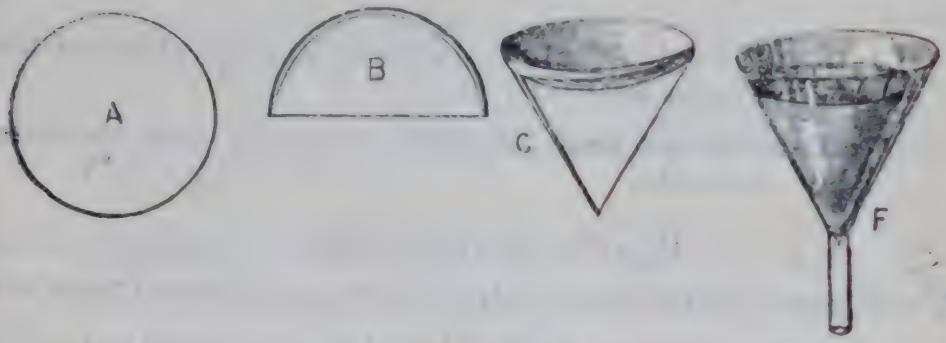

Fig. 120. Fig. 121. Fig. 122. Fig. 123.

Ans:—Fig. 120, (the paper is cut round). Figs. 121 & 122, (represent the way of folding it). Fig. 123, (it is put into a funnel). Fig. 111, (the liquid is filtered as shown in the figure.

Q. 853. How is nitric acid prepared in the laboratory? Give a sketch of the apparatus employed. Calculate the percentage of oxygen in nitric acid, and describe experiments which prove that it is a powerful oxydising agent.—Lon. Mat. 1903.

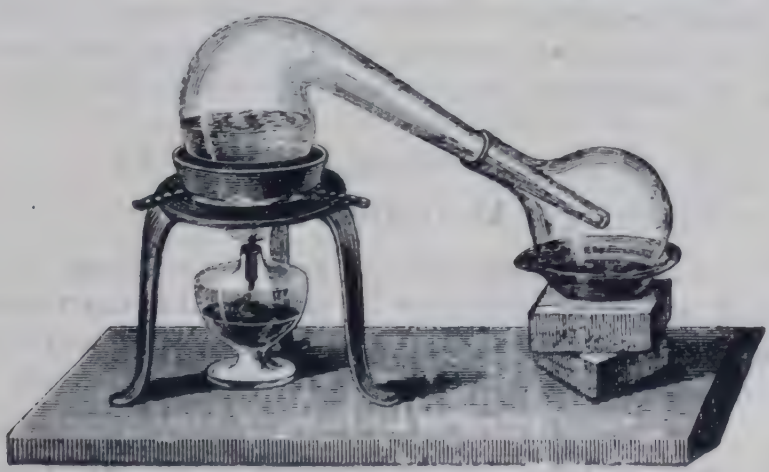

Fig. 124.

Ans. By heating a mixture of potassium nitrate and sulphuric acid in a retort and collecting and condensing the vapour (see fig. 124).

$HNO_3 = 1+14+48=63$.

63 parts of HNO_3 contain 48 of O.

$\therefore$ 100 parts of nitric acid $\frac{48}{63} \times 100 = 76{\cdot}2$ per cent.

Experiments to show that the acid is a powerful oxydising agent.—

(1) Introduce a red hot splinter of wood, carefully, into the acid and it burns brilliantly in it.

(2) Put into the acid some tin and it at once becomes converted into an oxide.

Q. 854. (1) Mention all the substances produced when salt, manganese dioxide and sulphuric acid are heated together.

(2) Account for the fact that chlorine is evolved when sulphuric acid is added to a mixture of the other two substances, whereas, when it is added to each separately, no chlorine is evolved.—M. U. 1899.

Ans. (1) The substances produced when the given mixture is heated, are sodium sulphate, manganese sulphate, steam, and chlorine.

(2) When sulphuric acid is added to manganese dioxide no chlorine is produced, for there is no chlorine in either sulphuric acid or manganese dioxide. When the acid is added to salt, hydrochloric acid is produced but no chlorine. When, however, the acid is added to the mixture and heated, the hydrochloric acid produced is acted on by manganese dioxide and chlorine is given out.

Q. 855. What is bleaching powder, and how is it employed for bleaching?—M. U. 1881.

Ans. Chlorine is stored up in the form of bleaching powder and is obtained whenever necessary by treating it with an acid. This important compound is manufactured by passing chlorine over slaked lime spread on the floor of chambers constructed for the purpose.

The article which is to be bleached is put into a mixture of bleaching powder and water. Then it is taken out and put into dilute hydrochloric or sulphuric acid. Chlorine is given out by the action of the acid on the powder and the gas acting on the colour removes it.

Q. 856. Give the ordinary method of preparation and the chief properties of hydrochloric acid.—M. U. 1891.

Ans. Hydrochloric acid is prepared by the action of sulphuric acid on common salt, when sodium sulphate and hydrochloric acid are produced.

Properties of hydrochloric acid :—

(1) It is extremely soluble in water.

(2) It forms the hydrochloric acid of commerce, when strongly dissolved in water, and is also known as 'Spirits of Salt' and 'muriatic acid.'

(3) It forms dense white fumes of ammonium chloride when it is brought into contact with ammonia.

(4) With metals or metallic oxides it forms salts known as chlorides.

(5) It has a strong acid reaction and turns blue litmus red.

(6) It is heavier than air and may be collected over mercury.

Q. 857. In what forms does phosphorus exist, and how do they differ from each other? Mention the purposes for which they are used.—M. U. 1903.

Ans. Phosphorus exists in two forms. The yellow or crystaline variety and the red or amorphous variety. The former is used in the manufacture of ordinary lucifer matches, and the latter in the manufacture of safety matches.

Difference between the two varieties .—

Ordinary Phosphorus.	Red or Amorphous Phosphorus.
1. At ordinary temperatures it is a semi-transparent yellowish solid of waxy consistency.	1. This is a red amorphous powder.
2. Sp. Gr. = 1·8.	2. Sp. Gr. = 2·4.
3. Melts very readily and is inflammable.	3. Does not melt readily and is not inflammable.
4. Soluble in carbon disulphide.	4. Insoluble in CS_2.
5. It crystallizes from its solutions in octohedrons.	5. This has no crystalline form.
6. This is very poisonous.	6. Not poisonous.

Q. 858. In what forms is sulphur usually met with? Mention some of the principal uses to which this element is put. How may it be made to combine with copper, and

what weight of it should be taken in order that 50 lbs. of copper may be combined?—M. U. 1894.

Ans. Sulphur is met with as roll sulphur or brimstone in the form of cylinders, and also as flowers of sulphur, which is a fine powder.

(1) *Uses of Sulphur :*—In the manufacture of ordinary lucifer matches. (2) In the manufacture of sulphuric acid. (3) In the manufacture of gunpowder. (4) In some medicines.

Heat both of them to the required temperature and then mix them ; the two elements unite glowing, and form copper sulphide. CuS, is the formula of copper sulphide. This tells us that 63 parts of copper combine with 32 parts of sulphur by weight. Therefore 50lbs.of copper combine with $\frac{32}{63} \times 50 = 25{\cdot}4$ lbs. of sulphur nearly.

Q. 859. with reference to sulphur and phosphorus, state (1) how each occurs in nature ; (2) in what forms each is known ; (3) in what respects the several forms of each element differ from each other ; (4) the purposes for which they are used ; and (5) describe in detail what takes place when each is heated in a spoon over a flame.—M. U. 1902.

Ans. (1) Phosphorus always occurs in a combined state ; and sulphur occurs both in combined as well as free states.

(2) Phosphorus is known in two varieties—red and yellow Sulphur is known in three varieties-octohedral, prismatic and plastic

(3) Sulphur :—

Structure.	Formation.	Sp. Gr.	Solubility in CS_2.
Octhohedral.	When sulphur is leposited from its solutions.	2·5	Soluble in carbon disulphide.
Prismatic.	When sulphur cools from its molten state	1·91	Soluble in CS_2.
Plastic. (amorphous)	When sulphur is melted and suddenly cooled after attaining a certain stage.	1·36	Insoluble.

For the difference in the varieties of phosphorus read answer to Question 857.

(4) Red phosphorus is used in the manufacture of safety matches and yllow phosphorus is used in the manufacture of ordinary lucifer matches. It is also used in medicine. Sulphur is used in the manufacture of (1) gunpowder, (2) sulphuric acid, (3) lucifer matches and (4) some medicines.

(5) When phosphorus is heated, it takes fire in a short time and burns, giving rise to white dense fumes of phosphoric anhydride.

When red phosphorus is heated, the same thing happens, but it takes a longer time to burn.

When sulphur is heated it begins to melt at a certain temperature, and as the temperature rises, it forms a yellow transparent liquid. If the heat be continued, the colour changes from yellow to brown and then to black. Now it becomes so thick that it cannot be poured out of the cup. If, however, the heat be continued, the pasty mass once more becomes liquid enough to be poured out of the vessel, and if heated further escapes as vapour and may burn away forming sulphur dioxide.

Q. 860. What are the different forms in which free carbon occurs in nature, and how do these forms differ from each other? In combination with what other elements does carbon exist in animal and vegetable matter, and how do plants obtain their carbon? Mention two other elements which, like carbon, exist in more than one form.—M.U. 1890.

Ans. Free carbon occurs in nature as diamond, graphite and coal.

Physical properties.	Diamond.	Graphite.	Coal.
Structure ..	Occurs in octohedral crystals.	Occurs as crystals of six-sided regular plates.	No crystalline form.
Colour ..	Brilliant white.	Greyish-black	Black.
Hardness ..	Hardest known substance.	Less hard	Less hard.
Sp. gravity ..	About 3·5.	About 2·5	About 1·8.
Conductivity.	Does not conduct electricity.	Conducts electricity.	A bad conductor of electricity.

In animal and vegetable matter carbon occurs in combination with hydrogen and oxygen.

Plants obtain their carbon from carbonic acid gas in the air. In the presence of sunlight plants decompose the gas, use up carbon for their growth, and give up oxygen.

Sulphur and phosphorus are two other elements which exist in more than one form just like carbon.

Q. 861 Coal, it is said, contains carbon and hydrogen. How could you prove the presence of both these elements in coal ?—M. U. 1887.

Ans. In a jar containing a small quantity of lime water at the bottom burn a piece of coal. After sometime shake the bottle and notice the milkiness in the lime water. Carbon of the coal combining with the oxygen of the air forms carbon dioxide and this gas acting on lime water turns it milky.

In another clean jar burn another piece of coal. The sides of the jar will be seen to become dim with the formation of fine drops of water. Hydrogen of the coal combining with the oxygen of the air gives rise to these drops of water.

Q. 862. Diamond, Black lead and Charcoal are said to be chemically the same substance. How can it be shown that this is the case ?—M. U. 1894.

Ans. Take equal weights of the three and burn them in a jar of oxygen. On examination it will be found that equal quantities of carbon dioxide are formed. This shows the chemical identity of the three substances.

Q. 863. When a piece of coal is burnt in air it disappears leaving behind a little ash. What is the composition of this ash, and why does it not also disappear ? What constituents of the coal have disappeared ; and how could you prove that they have not been destroyed, but only changed in form ?—M.U. 1893.

Ans. The ash is composed of the mineral impurities in the coal and consists of potassium carbonate, &c. The temperature is not sufficiently high to make it disappear. Only the carbon and the hydrogen of the coal have disappeared in another form. For the the answer to remaining part of the question, read the answer to question 861.

Q. 864. Describe the changes which occur when coal is heated in (1) an open vessel, and (2) a closed vessel furnished with a delivery tube.—M. U. 1881.

Ans. (1) The components of coal combine with the oxygen of the air, and escape in the form of carbon dioxide and steam. The mineral impurities in it remain behind in the vessel in the form of ash.

(2) Numerous solid, liquid and gaseous products will be the result. At last some carbon will be left behind in the form of coke.

The reason is this; under the influence of heat the various components of coal decompose and rearrange themselves, and in doing so give rise to various substances. Owing to the great percentage of carbon in coal, some carbon is left behind in the retort and is known as coke. The products of coal in this process may be classified under four heads (1) coke, (2) coal tar, (3) ammonaical liquor, and (4) coal gas.

Q. 865. Describe how you would prove that (*a*) coal gas is lighter than air, and that (*b*) it contains carbon and hydrogen. Explain the principles of the Davy's Safety Lamp.—M. U. 1902.

Ans. (a) A baloon filled whith coal gas rises in the air. This ploves that coal gas is lighter than air. (b) When coal gas is burnt in a jar with clean sides, minute drops of water will be seen on the sides. Hydrogen of the gas combining with oxygen of the air gives rise to these drops. If into this jar some lime water is poured and shaken, it becomes milky white showing the presence of carbon dioxide in it. This carbon dioxide is formed by the union of the carbon of the gas with the oxygen of the air.

Principles of Davy's lamps:—(1) Bodies do not burn till they reach a certain temperature, however combustible those bodies may be.

2 Wire gauze conducts away heat quickly, so that when burning gases pass through it, they cease to burn; they go out as unburnt gases.

Q. 866. What is 'fire-damp' and how are explosions in coal mines produced by it? Explain the action of Davy's Safety Lamp in preventing explosions. Persons who go down

a coal mine immediately after an explosion are frequently suffocated. How do you account for this?—M. U. 1888; 1902.

Ans. ***Fire damp*** is the common name for marsh gas. A mixture of this gas and air explodes if set fire to. In coal mines we have marsh gas. When light is taken into the mixture of the gas and air, an explosion takes place. The cause of the explosion is that carbon dioxide and steam are produced when the mixture is set fire to; the steam condenses into water; the surrounding air rushes in to fill the vacant space caused by the condensation of water vapour, and causes an explosion. The persons that go into coal mines soon after an explosion are suffocated on account of the carbon dioxide produced during the explosion.

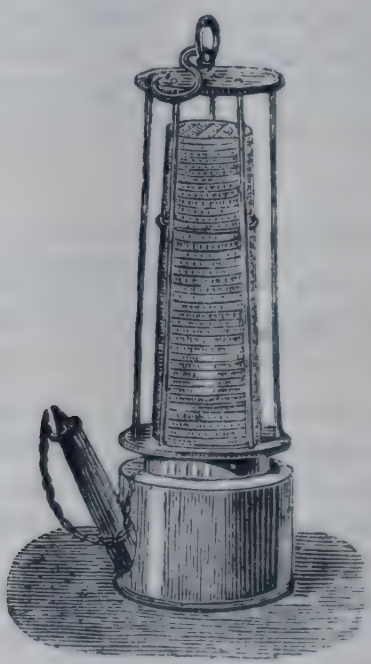

Fig. 125.

Although the explosive mixture may get into the flame of Davy's lamp (Fig. 125) and burn inside the wire gauze, the flame does not go out of the wire gauze because its heat is conducted away by the wire gauze; the flame is thus cooled below the point of ignition and unburnt gases only pass through the meshes.

Q. 867. Give instances of combustion, flame and incandescence and state how the phenomena differ from each other.—L. U. June. 1900.

Ans. Red hot charcoal in the oven is an example of a body undergoing combustion. White hot iron ball is an example of a body in incandescent state. Candle light and kerosine light are examples of flames.

Flame consists of gas in a state of burning. *Combustion* is the result of violent chemical action, and is always accompanied with heat and light. *Incandescence* is the white hot condition which a strongly heated body may assume.

Q. 868. Explain the terms 'combustible' and 'supporter of combustion' as applied to gases and why hydrogen and chlorine may be either according to circumstances.—M. U. 1883.

Ans. Combustible body is a body which can burn in the air. Supporter of combustion is a gas which allows other things to burn in it. Hydrogen is a combustible body, because it can burn in air; chlorine is not a combustible body, because it cannot burn in air.

However, by a special arrangement, chlorine may be made to burn in hydrogen; under these special conditions, chlorine may be said to be combustible.

Ordinarily, however, hydrogen burns in chlorine. So, hydrogen is a combustible body and chlorine a supporter of combustion under ordinary conditions.

Q. 869. (1) Which of the following elements are combustible and which are incombustible :—zinc, chlorine, silver, sulphur, iron, nitrogen, phosphorus, sodium?

(2) Arrange those which are combustible in the order of their combustibility, *i.e.*, the readiness with which they burn in air.

(3) Write the formula of the compound formed when each burns.—M. U. 1903.

Ans. (1) Sulphur, phosphorus, sodium, and zinc can burn in air, and so they are combustible bodies.

Chlorine, silver, iron and nitrogen cannot burn in air, and so they are incombustible bodies.

(2) Phosphorus, sodium, sulphur and zinc—in the descending order of combustibility.

(3) P_2O_5. : Na_2O. : SO_2. ; Zn O.

Q. 870. What is (i) aqua fortis, (ii) aqua regia, (iii) oil of vitriol, and (iv) soluble glass? Write these substances down in chemical nomenclature. B. U. 1899.

Ans. Aqua fortis is the popular name for nitric acid; aqua regia is the name given to a mixture of hydrochloric acid and nitric acid; oil of vitriol is the popular name for sulphuric acid.

Soluble glass is the common name for sodium silicate.

Q. 871. When a stream of burning alcohol is poured on a piece of wire-gauze, the liquid which passes through does not burn. Give an explanation of this phenomenon, and mention a useful application of the principle it illustrates. —M.U.

Ans. However combustible a body may be, it must reach a certain temperature in order that it may take fire and burn. This temperature is known as the *temperature of ignition.* Different bodies have different temperatures of ignition.

When burning alcohol is poured over wire gauze, the heat in it is conducted away to such an extent that the alcohol which passes through the gauze falls below the temperature of ignition; and, therefore the falling alcohol ceases to burn.

This principle finds a practical application in the construction of Davy's safety lamp. The instrument consists of an oil lamp surrounded by a wire gauze as shown in the figure 125. It can be taken into a place having combustible gases without the danger of their being set fire to. For, the gases may enter in and burn there, but when the flame tries to come out, it is cooled below the point of ignition by the wire gauze. Davy's lamp is, therefore, a useful help to workers in coal pits.

Q. 872. Explain the statement that oxidation occurs when a candle burns. How would you show this to be the case? Why does a candle flame give off so much light while the flame of hydrogen gives so little? —M.U. 1892.

Ans. Carbon dioxide and steam are produced when a candle burns in the air. Candle is composed of hydrogen and carbon. By the combination of the oxygen of the air these two substances are produced. Hence, when a candle burns oxidation occurs, because oxidation is the process of bodies combining with oxygen.

The light-giving power of a flame depends on the presence of incandescent solid particles in it. A candle flame contains incandescent solid particles of carbon in it and hence it is bright. Hydrogen flame has no incandescent solid particles in it and hence it is pale.

Q. 873. (*a*) Explain why hydrogen gives very little and coal-gas a great deal of light when burnt in the air.

(*b*) Describe an experiment by which the luminosity of the flame may be diminished.—M.U.

Ans. (*a*) Coal gas flame contains incandescent solid particles of carbon in it. Read the answer to the latter part of the question 872.

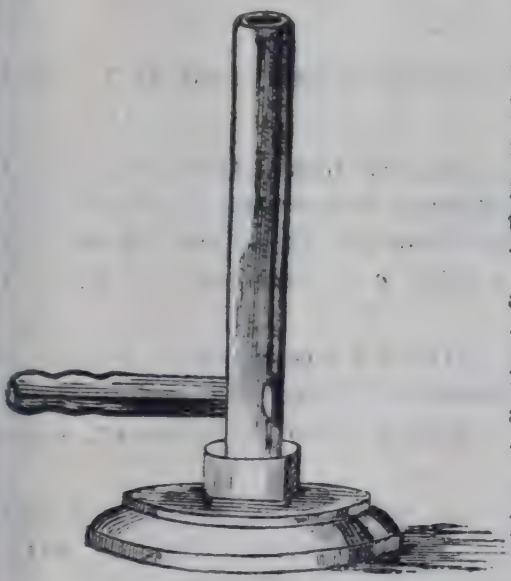

Fig. 126

(*b*) When air is admitted into the interior of a flame, it is made less bright. When coal gas is burnt in a Bunsen burner (Fig. 126) the gas burns with a pale flame when the holes at the bottom are open, but with a bright flame when they are closed. For, when the holes at the bottom are open the air enters in, mixes with the gas and burns away the carbon particles. Thus when the air is admitted into the interior of a coal gas flame its luminosity is diminished.

Q. 874. Of how many different parts does the flame of an ordinary candle consist? Mention the substances found and the changes taking place in each.

—M.U. 1883; 84; 95

Ans. The flame of an ordinary candle consists of three distinct parts. See Fig. 127.

In the inner zone there are unburnt combustible gases. In the middle zone the gases undergo an incomplete combustion. In this zone, therefore, we find unburnt particles of carbon. In the outer zone the combustion of the gases is complete.

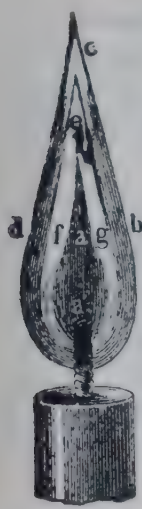

Fig. 127

The combustible gases produced in the wick, by the action of heat on the melted matter of the candle that has ascended into the wick, are stored up in the inner zone.

In the middle zone these gases, which are hydrocarbons, combine with oxygen, and the carbon particles separated, are raised to incandescence. Hence, it is this zone that contains unburnt particles of carbon in an incandescent state and gives light. It is also called zone of incomplete combustion. In the outer zone, the incandescent solid particles escape as carbon dioxide and the combustion is complete there. This zone is also called the zone of complete combustion.

Q. 875. Define the terms—acid, alkali, and salt, and give examples of each.—L.U.

Ans. *An acid* is a body which can turn blue litmus red, which has a sour taste, which contains hydrogen that can be displaced by a metal, and which is neutralized when brought into contact with a metal or metallic oxide, forming a salt; *e.g.*, sulphuric acid, and hydrochloric acid.

An alkali is a body which can turn red litmus blue, which is soapy to the touch and which can neutralize an acid forming a salt. Alkalies are formed when metallic oxides dissolve in water, *e.g.*, caustic potash, lime water.

A salt is a body which does not turn blue litmus into red or red litmus into blue and which is formed by the union of acids with alkalies, *e.g.*, calcium carbonate, washing soda, salt, nitre, etc.

Q. 876. Describe those properties possessed by sulphuric, hydrochloric and nitric acids, which lead to these substances being designated, "Acids."—L.U. June, 1900.

Ans. (1) These three are sour to the taste. (2) These three can turn blue litmus red. (3) These three contain hydrogen which can be exchanged for a metal. (4) When brought into contact with a base or alkali, a salt is formed, *e.g.*—

$$2\,NaOH + H_2SO_4 = Na_2SO_4 + 2H_2O.$$
$$KOH + HNO_3 = KNO_3 + H_2O.$$
$$ZnO + 2HCl = ZnCl_2 + H_2O.$$

SECTION III.

METALS.

Q. 877. Name the most important metallic elements, indicating which do and which do not occur in the free state. Mention what you consider to be the most important compound of each element and state anything of importance which you know concerning the compounds selected.

—M.U. 1889.

Ans. Iron, copper, zinc, magnesium, lead, silver, mercury, aluminium, and gold. Of these mercury, and magnesium, do not occur in the free state; the rest occur in the free state.

Compounds.	Uses.
1. Iron sulphate (green vitriol) ..	In the manufacture of ink.
2. Copper sulphate (blue vitriol).	Used for calico printing and also in medicine.
3. Zinc oxide (zinc white) ..	Used as a paint.
4. Magnesium sulphate	Epsom salts (used in medicine).
5. Lead chromate	Chrome yellow is used as a paint.
6. Silver nitrate	Lunar caustic; used in medicine.
7. Mercuric sulphide	This is called vermilion and is used as a paint.
8. Gold chloride	This is used in photography.

Q. 878. (1) What is meant by the *ore* of a metal?

(2) Write the name and state the chemical composition of one ore of each of the following metals:—iron, lead, zinc, copper, tin.—M. U. 1896; 1903.

(3) Explain why the metals aluminium and magnesium should be more costly than lead and zinc, although their ores are far more abundant.—M.U. 1903.

Ans. (1) An ore is the name given to the *natural* compound of a metal from which the metal can be extracted.

(2) ORE.	COMPOSITION.
Red Hæmatite.	Iron and oxygen.
Galena.	Lead and sulphur.
Zinc blende.	Zinc and sulphur.
Copper pyrites.	Copper, iron and sulphur.
Tinstone.	Tin and oxygen.

(3) The process of extracting aluminium and magnesium from their ores is much more difficult than the process of obtaining lead and zinc from their ores. Hence, those metals are more costly in spite of the abundance of their ores.

Q. 879. Mention one of the most important ores of iron, and state how the metal is obtained from it. In how many different forms is iron met with; how do they differ from each other in composition and properties, and for what purpose is each variety used? Mention a liquid which dissolves iron, the substance produced by its action, and a test by which the presence of iron in the solution may be recognised.

—M.U.1888.

Ans. Brown hæmatite

Method of obtaining iron :—

i. *First the ore is roasted.*—Impurities burn away and iron oxide remains behind.

ii. The roasted ore is then mixed with coal and limestone and smelted in a blast furnace (Fig. 128), the air necessary for the maintenanceofcombustion being supplied by a powerful hot blast, which is forced through pipes at the bottom of the furnace.

iii. The atmospheric oxygen of the hot blast coming into contact with the carbon forms carbon monoxide. This carbon monoxide comes in contact with the iron oxide, reduces it to iron, converts itself into carbon dioxide and escapes.

iv. As the molten iron descends, it comes into contact with carbon, unites with it, and runs down to the bottom of the furnace where it collects and is removed periodically. This is cast iron.

Cast Iron—Contains carbon from 3 to 5 per cent.: Is brittle and therefore cannot be forged and hammered: expands on solidifying from its molten state, which property makes it useful for founding.

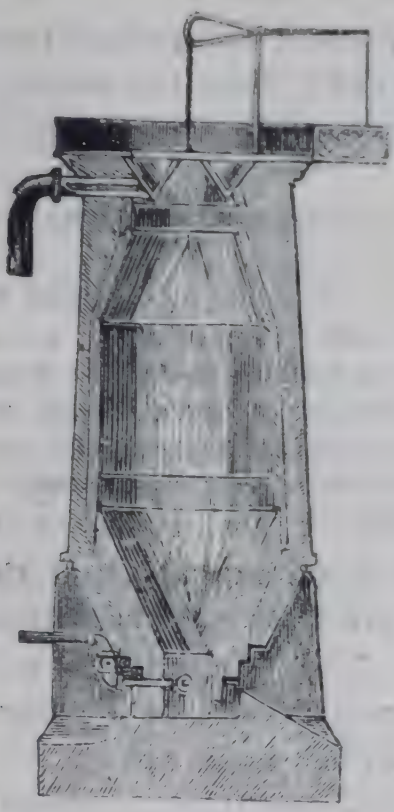

Fig. 128.

Wrought Iron.—Contains carbon from ·1 to ·5 per cent.: Can take up a high polish: Softens at a red heat; pieces of wrought iron are therefore welded, *i.e.*, joined together, when in that red hot state: is not brittle. Wrought iron, therefore, is used for all those purposes for which forging and hammering are necessary.

Steel.—Stands between cast iron and wrought iron in the proporiton of carbon. When heated and suddenly cooled it takes a temper, that is, becomes very hard. This property of steel makes it useful for razors, penknives, etc.

Sulphuric acid dissolves iron. Iron sulphate is formed during the reaction. By the addition of potassium ferrocyanide we can find

out the presence of iron in a solution. If iron be present in the solution, a blue precipitate is produced.

Q. 880 (1) How can the metal be obtained from iron rust?

(2) How would you produce Prussian blue from a solution of green virtriol? Give the reason for any precaution which may be necessary for the success of the test.

—M. U. 1901.

Ans. 1. By strongly heating iron rust along with charcoal, the metal can be obtained.

2. Add a few drops of nitric acid first and then by the addition of potassium ferrocyanide to the solution, we can have Prussian blue. The precaution to be taken is that a few drops of nitric acid should be added to the solution of green vitroil before hand. The reason for this precaution is that the ferrous salt may become ferric salt. Ferric salts give Prussian blue precipitate with potassium ferrocyanide, while ferrous salts give only a light blue precipitate with it.

Q. 881. Give the common name, and the composition, of the most important ore of each of the following metals :—Iron, copper, zinc, tin, lead. Describe a method by which lead may be obtained from its ore.—M. U. 1896.

Ans. Read the answer to question 878.

Method of obtaining lead from its ore :—Galena is the ore of lead from which the lead of commerce is obtained. Galena is lead sulphide. To obtain the metal from this ore, it is roasted with the addition of a small quantity of lime. The result of this is that a part of the ore is converted into lead sulphate and lead oxide, leaving the remaining part of the ore as it is. After sometime "the air is excluded and the heat of the furnace raised." Lead sulphate and lead oxide act on the remaining part of the ore and produce metallic lead.

Q. 882. What takes place when a piece of sodium is thrown into a basin of cold water? Compare this with what takes place when potassium is thrown on cold water, and account for the difference.—M. U. 1901.

Ans. Sodium floats on water and runs from place to place on it with a hissing noise assuming a globular form. The water acquires alkaline property, for it becomes a solution of caustic soda.

Potassium also floats on water. But there is this difference—a flame accompanies potassium, while no flame is seen with sodium. The water in this case also acquires alkaline properties as it becomes a solution of caustic potash. The heat produced by the union of potassium with oxygen of the water is sufficient to set fire to the hydrogen that is liberated. In the case of sodium the heat generated by the union of sodium and oxygen of the water is not enough to fire the escaping hydrogen. This is the reason for the flame accompanying potassium. The colour of the flame is due to the particles of potassium present in it.

Q. 883. What substances are used in making soap? Give some account of the process of its manufacture.—M. U. 1885.

Ans. All soaps are produced from the action of alkalies on oils and fats—potash and soda being the chief alkalies used. Palm oil, tallow and grease are the chief fatty matters used in the soap manufacture.

The oil from which soap is to be manufactured is boiled with a solution of caustic potash or caustic soda, when soap will be formed and remain in solution. Salt is then added to it. The salt dissolves in the water and separates the soap from it. [Cf. Q. 903.]

Q. 884. What is the name and the composition of the chief ore of tin? How is the metal obtained from the ore, and for what purpose is it used?—M. U. 1897.

Ans. Tinstone is the chief ore of tin and is composed of tin and oxygen.

The ore is crushed and washed. It is then mixed with lime and coal and strongly heated in a furnace. Metallic tin is produced and falls to the bottom of the furnace.

Owing to its power of resisting the oxidising action of the air, tin is largely used for coating iron plates.

Q. 885. You are given a thin strip of a white metal, and told to ascertain whether it is tin or zinc. How would you proceed?—M. U. 1903.

Ans. We can ascertain it:—(1) By bending the piece and noting if any crackling noise is made. The metal which makes a noise of that kind is tin.

(2) By noting the hardness also we can ascertain the metal. The harder of the two is zinc.

Q 886. Give the chief properties of the following metals:—Magnesium and Mercury.—M. U. 1891.

Ans. Magnesium.—(.) It is a silvery-white metal "which does not tarnish in dry air, but becomes coated with a film of oxide when exposed to air and moisture" (ii) When strongly heated in a current of steam, it decomposes steam, magnesium oxide being formed:—$Mg + H_2O = MgO + H_2$. (iii) When strongly heated in air it takes fire and burns brilliantly, forming its only oxide, magnesia MgO. Magnesium light, being rich in chemically active rays, is a good substitute for sunlight for photographic purposes. iv. HCl as well as H_2SO_4 dissolve it with evolution of Hydrogen.

Mercury.—(1) At the ordinary temperature it is a brigat silvery-white liquid metal which, when cooled to −39°C becomes a ductile and malleable solid. (2) It dissolves most of the metals (except iron and platinum). (3) It does not tarnish on exposure to the air, but oxidizes when heated. (4) HNO_3 dissolves it. HCl has no action upon it. H_2SO_4 dissolves it when hot.

Q. 887. Describe the appearance and properties of magnesium and of the ash formed when the metal is burnt in air. Is the magnesium contained in the ash or the ash in the magnesium? Give reasons for your answer.—M. U. 1898.

Ans. Magnesium is a silver-white metal. For its other properties read the question above.

The magnesium ash has a white colour and is solid. The metal is contained in the ash; because the metal combined with the oxygen of the air and formed magnesium oxide. The ash contains magnesium as well as oxygen in combination.

Q. 888. Mention the common metals and alloys you have seen which are white or nearly white in colour. In the case of the metals, describe any simple tests by which they can be distinguished from each other.

Ans. White alloys:—German silver, pewter, plumber's solder.

White metals:—Silver, mercury, tin, magnesium are the common instances of white metals. Lead is bluish.

Mercury can be known by its liquid state.

Tin can be distinguished by the characteristic crackling noise which it makes when bent.

Magnesium can be distinguished by the dazzling light with which it burns.

Lead can be distinguished by its leaving a mark on the paper when drawn on it.

Silver can be distinguished by the characteristic sound which it makes when struck, and also by its high conductivity of heat.

Q. 889. How will you show that a two-anna piece contains copper?—M. U. 1895.

Ans. Dissolve a small part of it in nitric acid. Remove silver from the solution by adding to it a solution of common salt. This forms silver chloride and precipitates all silver from it, which can be removed by filtration. Remove this by filtration. To the remaining liquid add a few drops of ammonia. A blue precipitate is formed, and this dissolves in excess, forming a blue solution, thus showing the presence of copper. [Or, by dipping a clean blade of steel knife, a deposit of copper may be seen on it.]

Q. 890. Gunpowder is made by mixing sulphur, charcoal and saltpetre. Is it a chemical compound of these substances? and if not a chemical compound, what is it? Give reasons for your answer.—M. U. 1882.

Ans. Gunpowder is a mechanical mixture of the substances mentioned. It is not a chemical compound, because it can be easily separated into its constituent things. If gunpowder is put into water, saltpetre dissolves and sulphur and charcoal remain at the bottom. By agitating the water strongly and leaving it to itself, the sulphur particles will be found deposited in the lower layers and the charcoal particles above the sulphur owing to the comparative lightness of charcoal.

Q. 891. You are given a powder consisting of charcoal and saltpetre. How would you separate the two substances from the mixture and obtain both in a pure state? What would be the result of heating the powder?—M. U. 1898.

Ans. Put the powder into water. Nitre dissolves in water and charcoal will be left behind. By filtration charcoal can be obtained.

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By evaporating the solution we may obtain saltpetre in the pure state.

The powder if heated sufficientiy will take fire and burn giving rise to carbon dioxide. This gas is formed by the union of charcoal with oxygen present in the saltpetre and which is given out when heated.

Q. 892. Charcoal will burn in the air, but if it be placed in a vessel from which the air is excluded, it will not burn. If however some nitre be mixed with the charcoal before it is placed in the vessel, the charcoal can be made to burn in spite of the exclusion of the air. Explain clearly why the charcoal burns in the vessel when nitre is mixed with it and not before. What important use has been made of this power which nitre possesses of making charcoal burn in spaces destitute of air?—M. U. 1886.

Ans. Charcoal requires oxygen to burn, and so it cannot burn in a place where there is no air or oxygen. But nitre contains the oxygen necessary to allow charcoal to burn away and so when the mixture is heated even in a place without air the charcoal burns away, because the nitre gives up to charcoal the oxygen necessary for its combustion. The important property of nitre whereby it makes charcoal burn in places without air has been used in the manufacture of gunpowder.

SECTION IV.—GENERAL.

Q. 893. How is clear lime water prepared? Describe and explain the changes which take place when (1) carbon dioxide is passed into lime water; (2) the gas is continued to be passed into lime water for a long time; (3) the resulting liquid in the second case is boiled.—M. U. 1901.

Ans. Fresh quick lime or slaked lime is put into water and shaken well. The whole is allowed to be at rest for some time. The clear water above is filtered. This is lime water.

(1) The clear water becomes milky white in appearance. Carbon dioxide combines with lime in the lime water and forms calcium car-

bonate. This calcium carbonate is a white and insoluble substance, and when it remains floating in the liquid, makes it look milky white.

(2) If the gas be passed for a long time the milkiness disappears. Calcium carbonate is generally insoluble, but can dissolve in water containing carbon dioxide in solution. So the calcium carbonate formed dissolves in the water on account of the excess of carbon dioxide passed into it, and makes it clear.

(3) By boiling the liquid it becomes milky white once more. The carbon dioxide escapes and the calcium carbonate held in solution by water is thrown down and the water, therefore, becomes milky white again.

Q. 894. Describe an experiment with which you are acquainted to illustrate the fact that when a chemical change occurs, there is neither gain nor loss of weight, but the bodies resulting from the action have exactly the same weight as the bodies which took part in it.—M. U. 1887.

Ans. Take a large clean flask. Put a piece of phosphorus in it. Fit it with an air-tight cork. Weigh all these accurately and note down the weight. Fire the phosphorus inside by the touch of a hot wire, and cork the flask immediately after removing the wire. At once the phosphorus will be seen to burn giving rise to white fumes. After the phosphorus has ceased to burn, weigh the flask with its contents again. It will weigh exactly the same as before. Thus you see that, although the phosphorus inside disappears, it is not destroyed.

Q. 895. Explain why, when phosphorus is burnt in a vessel containing air inverted over water, both the volume and the weight of the air are greatly diminished; but when charcoal is burnt, the volume is only slightly diminished and the weight is increased.—M. U. 1899.

Ans. When phosphorus is burnt in air, phosphoric anhydride is produced on account of the union of phosphorus and oxygen. So when phosphorus burns in air, the oxygen of the air is consumed. The phosphoric fumes dissolve in water freely. Hence, a part of the air in the bell-jar, namely, oxygen, dissolves in the water below (in combination with phosphorus.) So the volume and the weight of the *air* in the bell-jar are both diminished.

When charcoal is burnt in air, carbon dioxide is produced on account of the union of carbon with the oxygen of the air. Here also the oxygen of the air is consumed. But carbon dioxide formed dissolves in water only to a small extent, so that only a small portion of oxygen in the bell jar dissolves in the water below. The remaining oxygen remains in the air in combination with carbon. The volume of the air in the bell-jar is slightly diminished on account of the small quantity of carbon dioxide dissolved in the water below. The weight of the air in the bell-jar is increased owing to the presence of carbon in it in the form of carbon dioxide.

Q. 896. Complete the following equations and explain fully their meaning :—

$$KNO_3 + H_2SO_4 =$$
$$Na\ NO_3 + H_2SO_4 =$$

Supposing that the compounds represented by the formulæ KNO_3 and $Na\ NO_3$ were of the same price, which would be the more economical compound to use in the manufacture of nitric acid? Give the reasons for your answer.

(The atomic weights of Nitrogen, Oxygen, Sodium, Sulphur and Potassium are 14, 16, 23, 32 and 39 respectively.)—M. U. 1886.

Ans.

KNO_3	$+H_2SO_4$	$=KHSO_4$	$+HNO_3$
[39+14+48]	+[2+32+64]	=136	+63
$Na\ NO_3$	$+H_2SO_4$	$=Na\ HSO_4$	$+H\ NO_3$
[23+14+48]	+98	=[23+1+32+64]+	63.

The price being the same, sodium nitrate would be the more economical substance to use. To get 63lbs. of the acid we require 101 lbs. of potassium nitrate; but only 85lbs. of sodium nitrate will enable us to have the same quantity of nitric acid. Hence sodium nitrate is the more economical compound.

Q. 897. You are given a powder and told to ascertain whether it consists of bluestone mixed with alum or of the first substance only. How would you proceed?—M. U. 1900.

Ans. When a solution containing bluestone or alum is slowly evaporated, the substance in solution assumes a crystalline form. The crystalline form of alum is octohedral and is different from that of copper sulphate which is shown in Figs. 114 and 115. When the

mixture of the two is dissolved in water and the solution is slowly evaporated, the two substances separate in their respective forms. Hence, the given powder is to be dissolved in water and allowed to crystallize. The crystals formed are to be examined. If they are all in the shape of bluestone crystals, the absence of alum is to be inferred. If, however, you find white crystals of alum, the presence of alum is to be inferred.

Q. 898. State the composition and principal properties of ammonia. What happens when it is mixed (*a*) with water, (*b*) with nitric acid?—L. U., 1899. June.

Ans. Composition is NH_3. *Properties of ammonia.*—1. "Ammonia is a colourless gas possessing a peculiar pungent odour well known as that of smelling salts" 2. It is lighter than air and has a strong alkaline reaction. 3. It is exceedingly soluble in water. 4. It is unable to support combustion and is irrespirable (not fit for respiration). 5. It is not combustible under ordinary conditions, but if the air be heated or if the amount of oxygen be increased, the gas will burn with a yellow flame.

When mixed with water, the gas dissolves in the water and ammonium hydroxide is formed. The formula of the thing produced is NH_4OH.

When mixed with nitric acid it neutralizes the acid forming the salt, ammonium nitrate. Its formula is NH_4NO_3.

Q. 899. Silver chloride is an insoluble and cupric chloride a soluble salt. Explain clearly how, taking advantage of the above facts, the silver could be separated from the copper in a solution containing silver and cupric nitrates; supposing that you had succeeded in separating the silver from the copper, how would you proceed to test the copper?—M. U., 1886.

Ans. Add a solution of common salt to the given solution. This acts chemically on the substances in the given solution and forms silver chloride, copper chloride and sodium nitrate. Silver chloride being insoluble is thrown down in the form of a white precipitate. This may be separated by filtration. Copper chloride and sodium nitrate remain in solution.

By introducing a blade of clean iron into the solution left behind, metallic copper will be deposited on the iron blade, for iron can displace copper from its solutions. Or, a few drops of ammonium hydroxide may be added to the solution, when the presence of copper in it may be ascertained by the blue precipitate produced.

Q. 900. Describe an experiment by which diamond may be distinguished from common rock-crystal.—M. U. 1883.

Ans. Burn the given substance in oxygen. If carbon dioxide be formed, the given substance must be taken to be diamond. But if no change takes place in the substance, it is rock crystal (silica).

Q. 901 The following experiments are performed :—

(1) A piece of phosphorus is burnt in a bell-jar containing air placed in a shallow vessel full of water and after the combustion is finished, the apparatus is allowed to stand for sometime ; (2) a piece of sodium is placed on the surface of hot water contained in a vessel. Describe accurately what is observed to take place. and what properties have been acquired by the water.—M. U., 1898-R.

Ans. (1) White fumes of phosphoric anhydride will be seen. These fumes dissolve in the water, and the water rises to about a fifth of the bell-jar. The water acquires acid properties.

(2) If the water be sufficiently hot, the piece of sodium is accompanied by a flame which is yellow. A noise also is heard. But if the water be not sufficiently hot, only the noise is heard and no flame accompanies it. Sodium in either case combines with the oxygen of the water and dissolves in the remaining water. The water, therefore, acquires alkaline property.

Q. 902. Draw a diagram and explain the construction of a blow-pipe. Explain how it can be used to obtain metallic copper from bluestone.—M.U. 1902 R.

Fig. 120.

Ans. Blow-pipe is an instrument by means of which any part of a flame can be blown in the required direction. It consists of a conical tube (fig 129) the broader part of which is closed. A little above the broader part is a narrow tube at right angles, which ends in a fine hole.

Powder the bluestone; mix it with sodium carbonate ; and put it in the pit made on a piece of charcoal. Direct the reducing flame on it by means of the blow pipe. Metallic copper will be left behind after some time. This is because the sodium carbonate, charcoal and the reducing flame acting on copper sulphate form new compounds and leave behind copper.

Q. 903. How would you prepare soap in a small quantity? Describe the chemical actions involved in soap-making. What is the difference between hard and soft soaps?—All. U. 1902.

Ans. 'Boil in a vessel about four ounces of tallow or castor-oil with a solutin of forty grams of caustic soda in 250 c. c. of water for an hour or two. After cooling, add a strong solution of sodium chloride. The soap formed will separate and rise to the top of the solution, where it will finally, become a solid.' The acid of the fat combines with the metal of the alkali, and forms a soluble salt. This is *soap*. In the manufacture of hard soaps, soda is used, while caustic potash is used in the manufacture of soft soaps.

Q. 904. Describe fully the action of soap in washing. —Pun. Ent. 1903.

Ans. *In washing*, soap dissolves the oily film on the surface of the skin and thus makes it easy for us to remove the dirt from the skin, since the oil which held it, has been removed by the soap.

Q. 905. Describe what occurs and name all the products obtained when (1) red oxide of mercury is heated, (2) steam is passed over red-hot iron, (3) sulphuric acid is poured on zinc, (4) powdered antimony is put into chlorine, (5) sulphur is burned in the air, (6) chalk is heated.

—M. U. 1890.

(1) Mercuric oxide is decomposed into mercury and oxygen. Heat decomposes the oxide. Mercury is left behind and oxygen goes out.

(2) The oxygen of the steam is taken up by the iron, and its hydrogen is liberated. The products are iron oxide and hydrogen.

(3) The two act on each other chemically. Zinc displaces the hydrogen of the acid, forming zinc sulphate which remains in solution. The products are zinc sulphate and hydrogen.

(4) Antimony combines with chlorine directly. The combination is so powerful that sparks are seen to accompany it. A dense white cloud of antimony chloride is formed.

(5) Sulphur burns with a pale light producing sulphur dioxide, which can be recognised by its characteristic smell.

(6) Chalk, when sufficiently heated, undergoes decomposition. The products are calcium oxide and carbon dioxide.

Q. 906. What takes place when—(1) Potassium is thrown on water; (2) Phosphorus is burnt under a bell-jar placed over water and the white fumes allowed to dissolve; and (3) When the liquids thus obtained are mixed, and then evaporated to dryness?—M. U. 1883.

Ans. (1) Read the answer to question 882.

(2) The water rises into, and fills about a fifth part of, the jar; the fumes dissolve in the water below and form phosphoric acid.

(3) A salt is formed by mixing the two liquids—the alkali neutralizing the acid; and this is left behind on evaporating the mixture.

Q. 907. What chemical changes take place when lime stone is burnt?

(2) Mention two respects in which the substance left behind differs from the chalk or limestone.

(3) Explain the method of calculating the quantity of this substance which can be obtained from any given quantity of limestone.—M. U., 1900.

Ans. (1) Limestone is decomposed into calcium oxide (quicklime) and carbon dioxide. The gas escapes and quicklime remains behind.

(2) When the substance left behind is burnt, no carbon dioxide or any other gas is given out; but when chalk or limestone is burnt carbon dioxide is given out. When water is poured on the substance left behind, heat is produced and slaked lime is formed; but when water is poured on chalk or limestone no heat is produced nor does any chemical change take place.

(3) $Ca\,CO_3$ burnt = $Ca\,O + CO_2$.
$[40 + 12 + 48] = [40 + 16] + [12 + 32]$.

This equation tells us that 100 parts by weight of limestone yields 56 parts by weight of quicklime. Thus we can calculate the quantity of lime produced from a given quantity of limestone.

Q. 908. What occurs when (1) a piece of zinc is placed in a solution of lead acetate, (2) a piece of potassium is brought in contact with water, and (3) a mixture of common

salt, sulphuric acid, and manganese dioxide is warmed? —M. U., 1882

Ans. (1) Zinc displaces lead from its solutions. Therefore zinc takes the place of lead in the solution given. Lead will be deposited in the place of zinc.

(2) Read the answer to question 882.

(3) Chemical action takes place and chlorine gas is evolved. The other substances formed, namely, manganese sulphate, sodium sulphate and water remain behind.

Q. 909. Name five elements which undergo chemical changes by exposure to the air, either at ordinary or high temperatures. Describe briefly all the phenomena which accompany these changes and name the products. —M. U. 1894.

Ans. Phosphorus combines with the oxygen of the air when exposed to it: forms phosphoric fumes (P_2O_5) when burnt in air. Magnesium when burnt in air emits dazzling light and leaves behind magnesia, MgO. Iron when exposed to air becomes oxidised, forming iron rust.

Potassium when exposed to the air will be converted into potassium oxide aK_2O.

Sulphur when burnt in air produces sulphur dioxide (SO_2) which escapes as gas, producing irritating smell. Sulphur burns with a pale flame.

Q. 910. State the chemical changes which occur when (1) zinc fillings are strongly heated in air, (2) a bright piece of metallic iron is placed in a solution of sulphate of copper, (3) nitre and sulphuric acid are mixed together and heated.—M. U., 1884.

Ans. (1) Zinc burns forming zinc oxide.

(2) Iron displaces copper from its solutions. Therefore iron takes the place of copper forming iron sulphate and copper is deposited in the place of iron.

(3) Both the substances act chemically on each other. Nitric acid comes out in fumes and can be collected and condensed. Potassium sulphate remains behind.

Q. 911. What chemical changes take place when the following substances are heated;—(1) Chlorate of potash, (2) phosphorus, (3) chalk, (4) red oxide of mercury, (5) sulphur, (6) a mixture of saltpetre and sulphuric acid?—M. U., 1882.

Ans. (1) When chlorate of potash is heated it decomposes into potassium chloride and oxygen. Potassium chloride remains behind and oxygen is given out.

(2) Phosphorus, when heated in air, combines with oxygen and forms phosphoric anhydride.

(3) When chalk is burnt in air, it is decomposed into calcium oxide and carbon dioxide.

(4) Read the answer to question 905.

(5) After some time, sulphur burns with a pale flame and disappears as sulphur dioxide.

(6) Read the answer to question 896.

Q. 912. Name the compounds formed when the following elements are heated in air or oxygen:—Magnesium, sulphur, carbon, sodium, copper, phosphorus, zinc. Do the compounds thus produced exhibit any points of resemblance or difference? If so, name them.—M. U., 1889.

Ans. Magnesia, MgO; Sulphur dioxide, SO_2; Carbon dioxide CO_2; Sodium oxide Na_2O; Copper oxide, Cu O; phosphoric anhydride, P_2O_5; Zinc oxide, ZnO.

Resemblance in these oxides:—SO_2. CO_2 are gases. Mgo, Na_2O, CuO, P_2O_5 and ZnO are solids.

Difference in these oxides:—i. *Colour*; CO_2 and SO_2 are invisible; MgO, Na_2O, P_2O_5 and ZnO are white; CuO is black.

ii. *Solubility*: SO_2, P_2O_5, Na_2O dissolve in water freely; CO_2 and MgO slightly dissolve in water. ZnO and CuO, are insoluble in water.

iii, *Reaction*; Solutions of SO_2, P_2O_5, and CO_2 have acid reaction; while the solutions of Na_2O and MgO are alkaline.

iv. *Absorbing moisture*: Na_2O and P_2O_5 absorb moisture. Others do not.

Q. 913. Name the most important non-metallic elements which are met with in nature in the combined state only, also the most common compounds in which they occur. Mention some of the properties of each of these elements and state how any two of them may be obtained from the compounds which you name.—M. U. 1892.

A. Hydrogen ; Chlorine ; Phosphorus ; Silicon.

Important compounds :—water, common salt, bones, sand, respectively.

Properties of Phosphorus—Read question. 857

Properties of Chlorine—Read question. 851

Properties of Hydrogen—(1) ' 'Hydrogen is a colourless gas having neither taste nor smell.' (2) It is the lightest known substance, being 14·4 times lighter than air. (3) "Hydrogen is combustible and burns with a non-luminous flame, the temperature of which is very high." (4) Hydrogen is not a supporter of combustion. (5) Hydrogen is not poisonous, but cannot support life.

Ans. Properties of Silicon :—

AMORPHOUS SILICON.	CRYSTALLINE SILICON.
1. It is a dark brown powder.	**1.** This is a steel-black substance of metallic lustre, having octohedral shape.
2. Sp. Gr. = **2·15.**	**2.** Sp. Gr. = **2·4**
3. When heated in air or oxygen it burns forming SiO_2.	**3.** This does not burn in oxygen even when strongly heated.
4. It is insoluble in water and all acids except hydrofluoric acid in which it dissolves.	**4.** It is not soluble in any acid except a mixture of nitric and hydrofluoric acids.
5. Not so hard as crystalline silicon.	**5.** This is very hard and is able to scratch glass.
6. Not a good conductor of electricity.	**6.** This is a good conductor of electricity.

Hydrogen can be obtained by passing a current of electricity through water [to which a little acid has been added].

Chlorine can be obtained by heating a mixture of common salt sulphuric acid and manganese dioxide.

Q. 914. (*a*) Mention some elements which occur in the free state in nature, and some which do not.

(*b*) What are the names of the compounds which hydrogen forms with (1) chlorine, (2) oxygen and (3) nitrogen ?—M. U. 1882.

Ans. (*a*) Oxygen, sulphur, carbon, nitrogen, gold occur in the free state. Phosphorus, silicon, hydrogen, chlorine, aluminium do not occur in the free state.

(*b*) (1) Hydrochloric acid, (2) water, (3) ammonia.

Q. 915. You are provided with some sulphuric acid, copper, zinc and marble ; what gases can you prepare from these materials ? Describe the properties of the gases, and state how they can be distinguished from each other.

—M. U. 1898.

Ans. By means of sulphuric acid and copper we can prepare sulphur dioxide.

By means of the same acid and zinc, *hydrogen* can be prepared.

By the action of the acid on marble, carbon dioxide may be obtained.

Properties of Hydrogen : Read the answer to question 913.

Properties of carbon dioxide : 1. It is a colourless gas, having a feeble acid taste. 2. It cannot support combustion and so, a burning candle introduced into a jar containing this gas is extinguished at once. 3. It is heavier than air bulk for bulk. 4. When passed into lime water, the water is turned milky.

Properties of sulphur dioxide : 1. It is a colourless gas. 2. It is neither combustible nor a supporter of combustion. 3. It has a suffocating smell. 4. It is soluble in water.

How to distinguish these:—By its suffocating smell SO_2, may be distinguished from the rest. Of the remaining two that which is neither combustible nor a supporter of combustion, is carbon dioxide.

Q. 915. Explain the different ways in which gases may be collected, and state the way by which hydrogen and carbon dioxide may be collected.

Ans. (1) *Upward displacement* is the way in which a gas lighter than the air may be collected, and in this process the jar in which the gas is to be collected is turned upside down and the tube leading the gas is made to ascend right up to the bottom of the jar. (Fig. 130.)

(2) *Downward displacement* is the way in which gases heavier than air may be collected, and in this process the mouth of the jar collecting gas is held upwards and the tube leading the gas is allowed to go down to the bottom of the bottle. (Fig. 119.)

Hydrogen may be collected by upward displacement and carbon dioxide may be collected by downward displacement.

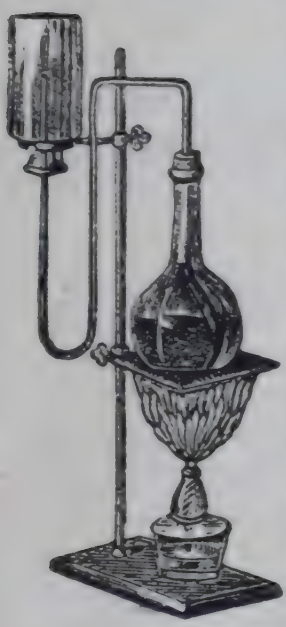

Fig. 130.

Q. 917. A person wants to descend into a well and wants to assure himself of the absence of carbon dioxide lower down the well. What would you advise him to do?

Ans. It would be well for him to send down first a lantern containing a lighted candle into the well. Let this lantern go down nearly to the surface of the water in the well and then be taken up. If the candle continues to burn inside, then the absence of carbon dioxide may be inferred and the man may safely go down. If the candle is extinguished, then the presence of carbon dioxide ought to be inferred, and it is not advisable for the man to go down.

Q. 918 Give the distinctive properties of hydrogen, chlorine and carbonic acid gas. State how you would collect each of these gases.—M. U. 1884.

Ans. Properties of H: Read Q. 913.

Properties of CO_2: Read Q. 915.

Properties of Cl: Read Q. 851.

Hydrogen may be collected by upward displacement, and the rest by downward displacement. If a purer form of the gas is

required, hydrogen and carbonic acid gas may be collected over water, but chlorine will have to be collected over hot water.

Q 919. Four glass cylinders are given you containing, respectively oxygen, hydrogen, nitrogen and carbonic acid. How would you identify the different gases?—M.U. 1881.

Ans. Introduce a burning taper into each of these. That in which the taper burns more brilliantly must be taken to contain oxygen. Of the remaining three jars, that in which the gas burns with a pale light must be taken to contain hydrogen.

In the remaining two in which the taper ceases to burn, pour lime water and shake the bottle. That in which the lime water turns milky must be taken to be the jar of carbon dioxide and the remaining one, that of nitrogen.

Q. 920. You are given six glass cylinders, each of which contains one of the following gases :—oxygen, air, hydrogen, nitrogen, hydrochloric acid, carbon dioxide. How would you identify each gas?—M. U., 1898.

Ans. Introduce into each of the cylinders a burning candle. Observe the effects produced. The jar in which the candle burns with greater brilliancy is the jar of oxygen. The jar in which the gas puts out the candle and burns itself with a pale flame, is the jar of hydrogen. The jar in which the candle continues to burn without any change is the jar of air. Into the remaining jar in which the burning candle ceases to burn, pour lime water and shake the bottle. That in which it is turned white is the jar of carbon dioxide. Into the remaining two pour some blue litmus solution. The jar in which it turns red is the jar of hydrochloric acid and the other, that of nitrogen.

Q. 921. Eight gases are shown to you, *viz.*, Oxygen, Hydrogen, Nitrogen, Chlorine, Carbon Monoxide, Carbon Dioxide, Ammonia and Sulphuretted Hydrogen. State the following particulars concerning each of them :—(1) its colour; (2) its smell ; (3) will it allow a lighted candle to burn in it? (4) will it take fire on application of a flame? (5) if you were making it would you try and collect it over water?—M. U., 1891.

Ans.

If the gas given be	The colour of it.	Smell.	Whether it will allow a candle to burn in it.	Whether it will take fire.	Whether it can be collected over water.
Oxygen ..	Colourless.	No smell ..	Yes ..	No ..	Yes.
Hydrogen ..	Colourless.	No ..	No ..	Yes ..	Yes.
Nitrogen ..	Colourless.	No ..	No ..	No ..	Yes.
Chlorine ..	Greenish Yellow.	Disagreeable ..	Yes ..	No ..	No.
Carbon Monoxide.	Colourless.	No smell ..	No ..	Yes ..	Yes.
Carbon Dioxide.	Colourless.	Slight ..	No ..	No ..	Yes.
Ammonia ..	Colourless.	Pungent ..	No ..	No ..	No.
Sulphuretted Hydrogen.	Colourless.	Disagreeable	No ..	Yes ..	No.

Q. 922. Describe the appearances, the preparation, and the uses of each of the following substances:—(1) Glauber salts, (2) bone ash, (3) copper oxide, (4) sodium amalgam, (5) red oxide of mercury.

By means of the last two substances illustrate the statement that "chemical combination takes place most readily between those bodies which least resemble one another."—M. U., 1902.

Ans.

Substance	Appearance.	Preparation.	Uses.
(1)	Colourless.	By the action of sulphuric acid on common salt.	(1) In the manufacture of sodium carbonate. (2) of glass and (3) some medicines.
(2)	White.	By burning bones in air.	In the manufacture of phosphorus.
(3)	Black.	By heating copper in air strongly.	Colors glass light green; decomposes organic compounds when heated with them.
(4)	White.	By mixing sodium with mercury.	It can decompose water.
(5)	Red.	By heating mercury strongly in air.	In preparing oxygen.

Chemical combination takes place readily between bodies resembling one another least:—For example, sodium and mercury are metals. They do not combine to form a compound, but only mix together and form an amalgam. But oxygen is a non-metal and mercury is a metal. These two do not resemble one another, but differ much. They two combine and form a compound.

Q. 923. Write the following names of substances in a column, and in parallel columns write opposite to each substance, (1) its constituents, (2) its appearance and any other property it possesses which you have observed:—Bone earth, galena, litharge, bleaching powder, green vitriol, antimony, sugar of lead, blende, flint, gypsum.—M. U. 1899 R.

Ans.

Name.	Constituents.	Appearance.	Property.
Bone earth.	Calcium, phosphorus, and oxygen	White.	Amorphous and little soluble in water.
Galena.	Lead and sulphur.	Grey.	Dissolves in hydrochloric acid, giving out sulphuretted hydrogen.
Litharge.	Lead and oxygen.	Light yellow.	Dissolves in acids forming lead salts.
Bleaching powder.	Calcium, oxygen, and chlorine.	White.	When any acid is added to it, chlorine is given out.
Green vitriol.	Iron, sulphur, and oxygen.	Light green.	It dissolves in water and produces a bluish precipitate with potassium ferrocyanide.
Antimony.	Element.	Bright and bluish.	When powdered and put into chlorine, the metal combines with it forming antimony chloride.
Sugar of lead.	Lead, carbon, hydrogen, and oxygen.	White.	When dissolved in water, the metal can be displaced by zinc.
Blende.	Zinc and sulphur.	Dark brown	Dissolves in acids producing sulphuretted hydrogen.
Flint.	Silicon and oxygen.	Dark.	No crystalline form.
Gypsum.	Calcium, sulphur, oxygen and water of crystallisation.	White.	Plaster of Paris is produced, when gypsum is properly heated.

Q. 924. Give the composition of the following substances: Saltpetre, lime, common salt, diamond, bone ash and glass.—M. U. 1884.

Ans.

Saltpetre	KNO_3	Potassium, nitrogen and oxygen.
Lime	CaO	Calcium and oxygen.
Common Salt	NaCl	Sodium and chlorine.

Diamond	C	Carbon.
Bone Ash	$Ca_3(PO_4)_2$	Calcium, phosphorus and oxygen.
Glass		Silica, lime and soda

Q. 925. Describe clearly what takes place when (1) Steam is passed over red-hot iron ; (2) dilute sulphuric acid is poured on iron-filings ; (3) a steel knife is dipped into a solution of copper sulphate ; (4) powdered antimony is dropped into chlorine.—M. U. 1881.

Ans. (1) Iron combines with oxygen forming an oxide of iron and hydrogen is liberated.

$$3\,Fe + 4H_2O = Fe_3O_4 + 4\,H_2.$$

(2) Iron forms green vitriol, and hydrogen is liberated.

$$Fe + H_2SO_4 = FeSO_4 + H_2.$$

(3) Iron displaces copper from its solutions. So, iron takes the place of copper forming iron sulphate, and metallic copper will be deposited on the steel knife.

$$Fe + CuSO_4 = FeSO_4 + Cu.$$

(4) Antimony combines with chlorine forming antimony chloride ; the chemical union takes place so violently that sparks are seen during the union of the two.

$$2\,Sb + 3Cl_2 = 2\,Sb\,Cl_3.$$

Q. 926. How are the following substances prepared and what are their properties :—Hydrochloric acid, epsom salts, green vitriol, nitric acid, quicklime and silver nitrate. —M. U. 1889.

Ans. **Hydrochloric acid :**—Refer to Q. 856.

Epsom salts:—Occurs in nature. It is formed also when magnesium or magnesia is dissolved in sulphuric acid. Dissolves in water and deposits from its solution in crystalline form.

Green vitriol :—By dissolving iron in sulphuric acid, this substance is produced. It is a reducing agent.

Nitric acid :—By heating a mixture of nitre and sulphuric acid, nitric acid is produced. It is a powerful oxydising agent.

Quicklime :—By burning limestone or shells quicklime is produced. It dissolves in water slightly. A mixture of this with sand and water is used for building purposes.

Silver nitrate :—By dissolving silver in nitric acid, silver nitrate can be obtained. When exposed to light, it turns dark.

Q. 927. State how the following substances are prepared and mention some of the properties of each :—Carbon dioxide, saltpetre, blue vitriol, potash, common salt, chlorine and sulphate of zinc. Express by means of chemical equations the reactions which take place in the preparation of any of these substances.—M. U, 1890.

Ans. **Carbon dioxide :**—Read Q. 915.

Saltpetre :—By gradual oxidation of nitrogenous matter in the presence of wood ashes and lime. Highly soluble in water; and is deposited in crystalline form from its solutions.

Blue vitriol :—By dissolving copper in sulphuric acid and evaporating the solution, copper sulphate is produced. From its solution, the metal can easily be displaced by iron.

Potash :—By the union of potassium and oxygen. It dissolves in water freely, forming caustic potash.

Common salt :—By evaporating the sea water, salt is obtained. Dissolves in water and crystallises from its solution.

Chlorine :—Read answer to question 851.

Zinc sulphate :—By dissolving zinc in sulphuric acid, the substance is obtained. Very greatly soluble in water.

(1) $Zn + H_2SO_4 = ZnSO_4 + H_2$.

(2) $MnO_2 + 2NaCl + 2H_2SO_4 = MnSO_4 + Na_2SO_4 + 2H_2O + Cl_2$.

Q. 928. State how the following substances are prepared, and mention some of the properties of each :—Quicklime, coal-gas, nitric acid, alumina, silver nitrate, soda.—M.U.

Ans :—**Quicklime** :—See answer to Q. 926.

Coal-gas :—This is prepared by submitting coal to destructive distillation. It burns in air and gives good light. It is lighter than air.

Nitric acid:—See answer to Q. 951.

Alumina :—Occurs in nature as ruby. Artificially prepared by burning aluminium in air. It is an amorphous powder.

Silver Nitrate:—Read Q. 926.

Soda :—By the union of sodium and oxygen, we can have soda. It absorbs moisture and forms caustic soda.

Q. 929. How are the following substances prepared and what are their uses :—Lime water, magnesia, sugar of lead, potash, calcium chloride, red oxide of mercury.—

M. U. 1893.

Ans.—**Lime water :**—By shaking quicklime or fresh slaked lime with water and filtering it. It is used for finding out the presence of carbon dioxide ; also as medicine.

Magnesia :—By burning magnesium in air. It is used in medicine.

Sugar of lead :—By dissolving lead in acetic acid. Used in calico printing.

Potash :—See Q. 927.

Calcium chloride :—By the action of hydrochloric acid on chalk. Absorbs moisture. It is used as a drying agent.

Red oxide of mercury :—Read Q. 922.

Q. 930. How are the following substances prepared :—Nitre, alumina, quicklime, epsom salts, soap?—M. U. 1894.

Ans.

Nitre :—Read answer to	Q.	927.
Alumina :—	Do.	928.
Quicklime :—	Do.	926.
Epsom salts :—	Do.	926.
Soap :—	Do.	903.

Q. 931. From what materials are the following substances prepared:—Nitric acid, phosphorus, lime, plate-glass, flint-glass, chlorine, saltpetre, and silver chloride ?—M U. 1883.

Ans.

Substances.	Materials.
Nitric acid	Sulphuric acid and nitre.
Phosphorus	Bone ash, sulphuric acid and charcoal
Lime	Limestone.
Plate-glass	Silica, lime and soda.
Flint-glass	Sand, potash, lead oxide.
Chlorine	Sulphuric acid, manganese d oxide and common salt.
Saltpetre	By gradual oxidation of stable manure, wood ashes, and lime.
Silver chloride	Sodium chloride and silver nitrate.

Q. 932. In what different ways can salts be obtained? Give illustrative examples.—L. U. 1902.

Ans: i. By the simple combination of bases and anhydrides :—

(1) $Na_2O + SO_3 = Na_2SO_4$.

(2) $CaO + CO_2 = CaCO_3$.

ii. By the action of hydroxides and acids —

(1) $2\,NaOH + H_2SO_4 = Na_2SO_4 + 2H_2O$.

$KOH + HNO_3 = KNO_3 + H_2O$,

iii. By the combination of basic oxides and acids :—

(1) $CuO + H_2SO_4 = CuSO_4 + H_2O$.

(2) $ZnO + 2HCl = ZnCl_2 + H_2O$.

iv. By the action of acids on metals :

(1) $Zn + H_2SO_4 = ZnSO_4 + H_2$

(2) $Mg + 2HCl = MgCl_2 + H_2$.

Q. 933. Give the chemical name, the component elements and one method of preparation of each of the following substances :—1. Epsom salts, 2. Green vitriol, 3. Chrome yellow, and 4. Slaked lime.—M. U. 1895.

Ans.—

No.	Chemical name.	Component elements.	Method of preparation.
1	Magnesium sulphate.	Magnesium, sulphur and oxygen.	By the action of sulphuric acid on magnesium.
2	Ferrous sulphate	Iron, sulpur and oxygen.	By dissolving iron in sulphuric acid.
3	Lead chromate.	Lead, chromium and oxygen.	By adding potassium chromate to lead acetate.
4	Calcium hydroxide.	Calcium, hydrogen and oxygen.	By pouring water on burnt limestone.

Q. 934. Describe the appearance and state what you know concerning the composition and properties of the following substances :—1. Washing soda, 2. gypsum, 3. Glau-

ber's salts, 4. oil of vitriol, 5. graphite, 6. galena, 7. marble, 8. alum, 9. litharge, 10. sugar of lead.—M. U. 1898.

Ans.

No.	Appearance.	Composition and properties.
1	Colourless and crystalline.	Na_2CO_3. It is an efflorescent salt; softens hard water.
2	Read Q. 923	.. .. ..
3	Colourless and crystalline.	Na_2SO_4: It is an efflorescent salt.
4	Oily-looking liquid.	H_2SO_4: It is a great attraction for moisture; it acts on metals to form sulphates.
5	Dull	Carbon: it marks paper.
6	Read Q. 923	.. .. ..
7	White	$CaCO_3$; takes up a high polish.
8	Colourless and crystalline.	Aluminium, potassium sulphur, oxygen, and water of crystallisation. When heated, it gives up its water of crystallisation and becomes powder.
9	Read Q. 923.	.. .. ..
10	White	Read Q. 926.

SECTION V.

Chemical Laws.

Q. 935. State the two most important laws of chemical combination, and explain them by a reference to any compounds of nitrogen.—M. U. 1886; 1895.

Ans. 1, "Chemical combination always takes place between definite masses of the elements that enter into combination." This is known as the law of chemical union in definite proportions. Take for example, the compounds of nitrogen and hydrogen called ammonia. It will always be found that 14 parts by weight of nitrogen have combined with 3 parts by weight of hydrogen to form the gas.

2. "When two or more elements combine in different proportions to form different compounds, then the masses of the elements combining with a constant mass of the rest always bear a simple relation." For example, nitrogen and oxygen combine in five different proportions to form five compounds—Nitrous oxide N_2O, Nitric oxide N_2O_2, nitrous anhydride N_2O_3, Nitrogen peroxide N_2O_4, Nitric anhydride N_2O_5. In these compounds the masses of oxygen that combine with two atoms of nitrogen are as 1 : 2 : 3 4 : 5.

These proportions are simple, for they are all multiples of the lowest one.

Q. 936. Under what conditions do chemical changes most readily take place? Give a few examples. How would you decide whether the change which a body has undergone is a chemical or a physical change ?—M. U. 1894

Ans. **1. Dissimilarity of the elements that unite** :—Sodium and mercury are both metals. When mixed, they form only a mixture called sodium amalgam Antimony is a metal, but chlorine is a non-metallic gas. Put powdered antimony into chlorine ; they combine at once forming antimony chloride.

2. Solution :—Silver nitrate and sodium chloride do not act on each other in solid state as quickly as they do in solution.

3. Powdery state:—Bits of antimony thrown into chlorine combine slowly with it, but powdered antimony at once combines with the gas.

[2 and 3 tell us that close contact is necessary, in order that chemical action may take place.]

4. Presence of another substance :—Potassium chlorate, when heated gives out oxygen after melting ; but if mixed with manganese dioxide and heated gives out oxygen at a lower temperature.

If the body produced is an entirely different one and its chemical properties are entirely different from those of the constituents, then a chemical change must be supposed to have taken place. The absorption or giving out of heat, also, must be noticed to enable us to know if a chemical change has taken place.

Q. 937. What is meant by the combining weights of the elements? When two elements combine to form several

compounds, how do the weights of the elements vary in those compounds? Exemplify your answer by reference to the compounds formed by any two elements you like. Explain also how their composition by weight is expressed by their formulæ.—M. U. 1893.

Ans. The combining weight of an element is the smallest proportion by weigh of that element which enters into combination—the combining weight of hydrogen being taken as the standard. When two elements combine to form several compounds, they do in different proportions. These proportions will be found to be the multiples of the lowest, e.g., five compounds of nitrogen and oxygen are known. The proportions of the masses of oxygen combining with the same quantity of nitrogen in each of the compounds are as 1 : 2 : 3 : 4 .5. The oxides are N_2O, N_2O_2, N_2O_3, N_2O_4 and N_2O_5. N_2O is the formula of nitrous oxide. N_2 represents two atoms of nitrogen, The atomic weight of nitrogen is 14 ; so N_2 represents 28 parts by weight of nitrogen. O represents one atom of oxygen. The atomic weight of oxygen is 16 ; so O represents 16 parts by weight of oxygen. Hence the proportion of nitrogen and oxygen in the compound is as 28 : 16 or as 7 : 4.

Q. 938. Explain what is meant by saying that the combining weight of oxygen is 16, and that of magnesium 24. How have these numbers been obtained? Describe an experiment which shows that when these elements combine, the weights which do so are in the ratio of these numbers.

—M. U. 1890.

Ans.—The smallest part of oxygen entering into chemical union is 16 times heavier than the smallest part of hydrogen which enters into chemical union. [Similarly, magnesium 24 times]. In most cases the atomic weight is the same as the combining weight. So, it may be said that one atom of magnesium is 24 times heavier than one atom of hydrogen.

These numbers are obtained by analysing a very large number of compounds containing the element. In the case of ordinary gases, by weighing equal volumes of them.

Weigh a certain quantity of magnesium and convert it into oxide. The oxide will be found to be $1\frac{2}{3}$ the weight of magnesium taken. This shows that magnesium combines with $\frac{2}{3}$ its weight of

oxygen. The proportion of the combining weight of magnesium to that of oxygen is 24 : 16 or 1 : $\frac{2}{3}$.

Q. 939. Explain 'chemical displacement' and calculate the quantity of iron necessary to displace the copper contained in four pounds of bluestone.—C. P.

[Cu = 63 ; Fe = 56 ; S = 32 ; O = 16].

Ans.—

Chemical displacement: (1) it is a form of chemical action ; (2) in this, an element that is contained in a compound which is dissolved in water is displaced by another element which has a greater affinity to the other components of the compound; (3) displacement takes place atom for atom, i.e., if ten atoms of the element dissolve, ten atoms of the element in the solution will be displaced ; (4) the weights of the element dissolved and of the element displaced are in the ratio of their atomic weights. Iron, for example, displaces copper from a solution of its compounds, say, copper sulphate. If ten atoms of iron dissolve, ten atoms of copper are deposited from the solution. The weight of iron dissolved will be to the weight of copper deposited as 56 : 63 or 8 : 9 [the atomic weight of copper being 63 and that of iron 56.]

Sol. $Cu\,SO_4 + Fe = Fe\,SO_4 + Cu.$

$(63+32+64) + 56 = (56+32+64) + 63.$

To displace copper contained in 159 lbs. of bluestone, we require 56 lbs. of iron.

$\therefore$,, 4 ..... $\frac{56}{159} \times 4 = 1{\cdot}4$ lbs.

SECTION VI.

Chemical Arithmetic.

Q. 940. If one litre of hydrogen weighs 0·0896 gramme, and oxygen is sixteen times as dense as hydrogen, how many litres of each gas are required to produce fifty grammes of water?—M.U. 1903.

Sol. $H_2O = [2+16]$.

18 grms. of water are formed by 2 grms. of H and 16 grms. of O.

$\therefore$ 50 grms. ,, ,, $\frac{2}{18} \times 50$ grms. of H and $\frac{16}{18} \times 50$ grms. of O

$\frac{896}{10000}$ grm. of H occupies one litre.

$\therefore \frac{50}{9}$ grms. of H ,, ,, $\frac{10000}{896} \times \frac{50}{9} = 62\frac{1}{2}\frac{1}{52}$ litres.

Again, $\frac{1}{10000}\frac{4}{8}\frac{8}{9}\frac{9}{6}$ grms. of O occupies 1 litre.

$\therefore \frac{400}{9}$ grms. of O occupies $\frac{10000}{16 \times 896} \times \frac{400}{9} = 31\frac{1}{56}\frac{1}{4}$ litres.

$\therefore$ We require $62\frac{1}{2}\frac{1}{52}$ litres of hydrogen and $31\frac{1}{56}\frac{1}{4}$ litres of oxygen to form 50 grammes of water.

Q. 941. Complete the equation $Zn + H_2 SO_4 =$

What weight of zinc and of sulphuric acid is required to yield 4 grains of hydrogen.—M. U. 1885.

Ans. $Zn + H_2SO_4 = ZnSO_4 + H_2$

$65 + [2+32+64] = [65+32+64] + 2.$

To obtain 2 grms. of H we require 65 grms. of zinc and 98 grms. of H_2 SO .

$\therefore$,, 4 grms. of H ,, 130 grms. of Zn. and 196 grms. of the acid. Ans.

Q. 942. How much sulphuric acid and nitre do you require to produce 9 pounds of nitric acid?

[$O = 16$. $K = 39$. $N. = 14$. $H = 1$. $S = 32$.]

Ans. The equation that represents the reaction is :—

KNO_3	$+H_2SO_4 =$	$HNO_3 +$	$KHSO_4$.
$39+14+48$	$+ \quad 2+32+64 \quad =$	$1+14+48 \quad +$	$39+1+32+64$
101	98	63	136

To get 63 lbs. of nitric acid we require 101 lbs. of nitre and 98 lbs. of sulphuric acid.

$\therefore$ to get 1 pound of HNO_3 we require $\frac{101}{63}$ lbs.

of KNO_8 and $\frac{98}{63}$ lbs. of H_4SO_4

$\therefore$ to get 9 lbs. ,, ,, $\frac{101}{63} \times 9$ or $14\frac{3}{7}$ lbs. of KNO_3

and $\frac{98}{63} \times 9$ or 14 lbs. of H_2SO_4.

Q. 943. What gas is formed when hydrochloric acid acts upon chalk or marble ($CaCO_3$)? How much of this gas by weight can be obtained by 100 lbs. of either of these materials?—M. U. 1887

Ans. Carbon dioxide is the gas formed.

$$CaCO_3 + 2HCl = CaCl_2 + H_2O + CO_2$$
$$[40+12+48] + 2[1+35{\cdot}5] = [40+71] + [2+16] + [12+32]$$

A 100 lbs. of chalk gives out 44 lbs. of CO_2, Ans.

Q. 944. How would you use chemical equations to ascertain the weight of sulphuric acid required to dissolve 100 lbs. zinc and the weight of chalk required to produce 100 lbs. of calcium chloride—M. U. 1888.

$S = 32$, $O = 16$, $Zn = 65$, $Ca = 40$, $C = 12$, $Cl = 35{\cdot}5$.

A. (1) $Zn + H_2SO_4 = ZnSO_4 + H_2$

$$65 + [2+32+64] = [65+32+64) + 2]$$

65 lbs. of zinc are dissolved by 98 lbs. of H_2SO_4

∴ 100 lbs. $\frac{98}{65} \times 100 = 150\frac{10}{13}$ lbs.

(2) $CaCO_3 + 2HCl = CaCl_2 + CO_2 + H_2O$.

$$[40+12+48] + 2[1+35{\cdot}5] = [40+2\times35{\cdot}5 + [12+32] + [2+16].$$

111 lbs. of calcium chloride are obtained from 100 lbs. of chalk.

∴ 100 lbs. ,, ,, ,, $\frac{100}{111} \times 100 = 90\frac{10}{111}$

Q. 945. Calculate the quantity of dilute sulphuric acid (containing 1 part by weight of sulphuric acid to four of water) required to produce 322 grains of zinc sulphate.

Sol. The equation representing the reaction is :

$$Zn + H_2SO_4 = ZnSO_4 + H_2.$$
$$65 + \underbrace{(2+32+64)}_{98} = \underbrace{(65+32+64)}_{161} + 2$$

To get 161 grains of zinc sulphate you require 98 grains of sulphuric acid.

∴ 1 ,, ,, ,, $\frac{98}{161}$ grs.

∴ 322 ,, ,, $\frac{98}{161} \times 322 = 196$ grs.

The acid given contains only 20 per cent. of sulphuric acid.

Therefore if one part of the acid is required, 5 parts of the dilute acid must be taken.

∴ if 196 grs. .. .. $196 \times 5 = 980$ grs. *Ans.*

Q. 946. Iron precipitates copper from solutions containing the latter metal. What compound is formed when

a plate of iron is placed in a solution of copper sulphate? Write an equation for the quantity of the compound referred to which can be obtained from 1 lb. of the copper salt.—

M. U. 1889.

Ans. The compound formed is iron sulphate.

$CuSO_4(sol.) + Fe = FeSO_4(sol.) + Cu.$

$[63+32+64]+56 = [56+32+64]+63.$

159 lbs. of $CuSO_4$ produces 152 lbs. of $FeSO_4$

1 lb. ,, ,, $\frac{152}{159}$ lb. of $FeSO_4$

Q. 947. Name the compound of copper which is formed when the metal is acted upon by sulphuric acid, and express the changes which occur, by an equation. How, and in what form can this compound be obtained from its solution, and by what tests could you recognise the presence of the metal in it? Calculate the weight of copper required to produce ten pounds of the compound in the manner referred to.—M. U. 1892.

[$Cu=63$, $S=32$, $O=16$, $H=1$.

Ans. Copper sulphate is the compound of the metal formed under the given conditions. This compound can be obtained from the solution by evaporating it. The presence of the metal in the solution can be recognised by the addition of ammonium hydroxide to it when a blue precipitate will be produced, which dissolves forming a deep blue solution when more of ammonia is added to it.

$Cu + 2H_2SO_4 = CuSO_4 + SO_2 + 2H_2O$

$63+2[2+32+64] = [63+32+64] + [32+32] + 2[2+16]$

For obtaining 159 lbs. of $CuSO_4$ we require 63 lbs. of copper.

∴ ,, 10 lbs ,, $\frac{63}{159} \times 10 = 3\frac{51}{53}$ lbs.

Q. 948. Describe the changes which occur when a stream of dry hydrogen is passed over heated black oxide of copper. If 158 grammes of copper oxide are heated, what weight of hydrogen is necessary to complete these changes?

—M. U. 1893.

Ans. The hydrogen combines with the oxygen of the copper oxide forming steam and leaves metallic copper behind.

$CuO + H_2 = H_2O + Cu$

$[63+16] + 2 = [2+16] + 63$

79 grs. of CuO require 2 grs. of H.
∴ 158 grs. ,, ,, 4 grs. of H.

Q. 949. What new compound is formed when a piece of iron is dissolved in sulphuric acid, and how would you separate this compound from the solution? How would you recognise the presence of the metal in this compound? Calculate the weight of the compound which is obtained by dissolving 10 lbs. of iron in sulphuric acid.—M. U. 1893.

Ans. Green vitriol [Ferrous sulphate] is formed. This can be obtained from the solution by evaporating it.

A solution of the compound in water has to be made; then a few drops of nitric acid have to be added to it; then a few drops of potassium ferrocyanide have to be added to that. If a Prussian blue precipitate is formed then the presence of iron in the compound may be inferred.

$$Fe + H_2SO_4 = FeSo_4 + H_2$$
$$56 + [2 + 32 + 64] = [56 + 32 + 64] + 2$$

56 lbs. of iron give rise to 152 lbs. of iron sulphate
10 lbs. ,, ,, $\frac{152}{56} \times 10 = 27\frac{1}{7}$ lbs.

Q. 950. What information is afforded by a chemical equation? Explain how a chemical equation is used to ascertain the weight of black oxide of copper required to convert 10 grammes of hydrogen into water.—M. U. 1888; 1894.

Ans. 1. It tells us the things that take part in the reaction and also those that are produced during the reaction.

2. The quantities of the things that take part in the reaction, and that are produced during the reaction can be ascertained by the help of an equation.

3. We can also learn from it that, although things may change form, the matter composing them is not destroyed.

$$CuO + H_2 = Cu + H_2O$$
$$[63 + 16] + 2 = 63 + [2 + 16]$$

Two grms of H. can have the necessary oxygen from 79 grms. of CuO.
∴ 10 grms ,, ,, 395 grms.

Q. 951. How is nitric acid prepared? What are its properties? Calculate the weights of the reacting substances

you should take in order to get 20 grms. of nitric acid. H : N : O : S : K : : 1 : 14 : 16 : 32 : 39.

A. By heating nitre with sulphuric acid and condensing the fumes that come out, nitric acid is obtained.

Properties and uses of nitric acid :—(1) "It is a colourless liquid having a specific gravity of 1·5. (2) It fumes strongly in the air and has a peculiar and choking smell. (3) It is extremely hygroscopic (for, it absorbs moisture with great readiness). (4) It is a powerful oxydising agent on account of the readiness with which it parts with oxygen". e.g., a quantity of strong nitric acid thrown upon sawdust causes it to burst into flame ; sulphur, when put into the acid, is at once converted into sulphuric acid ; a small piece of metallic tin put into a test tube containing a little of the acid is at once converted into tin oxide (SnO_2.)

$$2KNO_3 + H_2SO_4 = 2HNO_3 + K_2SO_4$$
$$2[39+14+48] + [2+32+64] = 2[1+14+48] + [78+32+64].$$

To get 126 grms. of nitric acid you must take 202 grms. of nitre, and 98 grms. of H_2SO_4

,, 20 grms. ,, $\frac{202}{126} \times 20$ of nitre and $\frac{98 \times 20}{126}$ of sulphuric acid, *i.e.*, $32\frac{4}{63}$ grms. of nitre and $15\frac{5}{9}$ of sulphuric acid.

Q. 952. How is lime obtained from chalk? What weight of the latter is required in order to obtain from it half a ton of the former. By what tests can lime be distinguished from chalk ?—M U. 1896.

A. By burning chalk lime can be obtained.

$CaCO_3$ when burnt $= CaO + CO_2$

$[40+12+48] = [40+16] + [12+32.]$

56 tons of lime can be had from 100 tons of chalk.

$\therefore$ $\frac{1}{2}$ a ton .. .. .. $\frac{100}{56} \times \frac{1}{2}$

$= 17\frac{6}{7}$ cwts. of *chalk.*

(1) By burning chalk carbonic acid gas is given out. (2) By pouring water on lime great heat is produced and slaked lime is produced.

Q. 953. The combining weight of oxygen is 16 and that of iron 56. Calculate the weight both of hydrogen and of iron oxide which will be produced, when 200 grammes of iron are

heated in a current of steam, if the oxide produced has the formula Fe_3O_4.—M. U. 1897.

Ans : $3\,Fe + 4\,H_2O = Fe_3O_4 + 4\,H_2$.

$[3\times56] + 4[2+16] = [3\times56+4\times16] + 4\times2$.

168 grms. of iron produce 232 grms. of Fe_3O_4 and 8 grms. of hydrogen.

∴ 200 grms. ,, ,, 276 $\frac{4}{21}$ grms of Fe_3O_4 and 9 $\frac{11}{21}$ grms. of H.

Q. 954. Magnesium is burnt in air and the product dissolved in sulphuric acid. Name all the substances produced, and calculate how much of each would be obtained from 10 grammes of the metal.—M. U. 1897.

Ans. When magnesium is burnt in air magnesium oxide or magnesia is produced. When magnesia is dissolved in sulphuric acid, magnesium sulphate and water are produced.

$MgO + H_2SO_4 = MgSO_4 + H_2O$

$[24+16] + [2+32+64] = [24+32+64] + [2+16]$.

24 grms. of magnesium produces 40 grms. of MgO.

∴ 10 grms. ,, ,, $\frac{10}{24}\times40 = \frac{50}{3}$ grms.

Again,

40 grms. of MgO produce 120 grms. of $MgSO_4$ and 18 grms. of water.

∴ $\frac{50}{3}$ grms. ,, ,, 50 grms. of $MgSO_4$ and $7\frac{1}{2}$ grms. of water.

Q. 955. Write an equation for the change which takes place when a mixture of potassium chlorate and carbon is heated, and calculate the weight of the chlorate required to oxidise 10 grammes of carbon to carbon dioxide.—M. U. 1898.

Ans :—$2\,KClO_3 + 3\,C = 2KCl + 3\,CO_2$.

12 grms. of carbon require 32 grms. of oxygen.

∴ 10 grms. ,, ,, $\frac{32}{12}\times10 = 26\frac{2}{3}$ grms. of O.

Again,

$2\,KClO_3$ heated = $2\,KCl + 3O_2$.

$2\,[39+35+48] = 2\,[39+35] + 3\times32$

∴ 96 grms. of oxygen are obtained from 244 grms. of Potassium chlorate.

$\therefore$ $26\frac{2}{3}$ grms. ,, $\frac{244}{96} \times \frac{80}{3} = 67\frac{7}{9}$. Ans.

Q. 956. A compound has the following percentage composition ;—43·4 of sodium, 11·3 of carbon and 45·3 of oxygen What is its formula and name ? [Na=23, C=12, O=16].

Sol. First of all find out the atomic proportion of each element by dividing each element by its atomic weight; thus :

$\frac{43{\cdot}4}{23} = 1{\cdot}87$ of sodium.

$\frac{11{\cdot}3}{12} = {\cdot}94$ of carbon.

$\frac{45{\cdot}3}{16} = 2{\cdot}83$ of oxygen.

Divide each of the quotients thus obtained by the lowest one Thus you have—

$\frac{{\cdot}94}{{\cdot}94} = 1$ of C ; $\frac{1{\cdot}87}{{\cdot}94} = 2$ of Na ; $\frac{2{\cdot}83}{94} = 3$ of O

The formula is Na_2CO_3 ; and the name of the thing is sodium carbonate.

Q. 957. Red oxide of mercury is heated (1) alone, (2) with carbon, (3) with hydrogen. What products are formed and what weight of each would be obtained from 10 gramme of the oxide—M. U.

Ans.—

(1) Mercury and oxygen.

2 HgO heated = $2\,Hg + O_2$

$\therefore$ 432 grms. of HgO give 32 grms. of O and 400 of Hg.

$\therefore$ 10 grms. ,, $\frac{32}{432} \times 10 = \frac{20}{27}$ of oxygen and $9\frac{7}{27}$ mercury.

(2) $8\,HgO + 4C = 8Hg + 4\,CO_2$

$8[200+16] + [4\times12] = [8\times200] + 4\,[12+32]$.

1728 grms. of HgO give us 1600 grms. of mercury and 1 grms. of Co_2.

$\therefore$ 10 grms. ,, $9\frac{7}{27}$ grms. of Hg and $1\frac{1}{54}$ of CO_2

(3) $HgO + H_2 = H_2O + Hg$.

$[200+16] + 2 = [2+16] + 200$.

216 grms. of HgO give us 18 grms. of water.

∴ 10 grms. ,, $\frac{5}{8}$ grms. of water.

Q. 958. What weight of carbonic acid is obtained by burning (*a*) fifty grains of carbon, and (what weight of oxygen by heating the same quantity of mercuric oxide?

—M. U. 1883

Sol. (*a*) CO_2 is the formula for carbon dioxide. It tells us that 12 parts by weight of carbon combines with 32 parts by weight of oxygen and forms 44 parts by weight of carbonic acid gas.

12 grains of carbon generate 44 grns. of CO_2

∴ 50 ,, ,, ,, $\frac{44}{12} \times 50 = 183\frac{1}{3}$ grns.

(*b*) HgO is the formula for mercuric oxide.

216 grains of mercuric oxide yields 16 grns. of O.

∴ 50 ,, ,, $\frac{16}{216} \times 50 = 3.8$ grns. of O.

Q. 959. State and explain the various forms of chemical action.

Ans.—1. *Chemical Combination.*—Where two or more things combine and form an entirely new substance, *e.g.*, iron and sulphur combine forming iron sulphide.

2. *Chemical Decomposition.*—When a compound body is split up into its constituents which are entirely different from the original substance, *e.g.*, when mercuric oxide is heated, it is decomposed into mercury and oxygen.

3. *Double Decomposition.*—Where two or more substances that react upon each other exchange their constituents giving rise to new substances, *e.g.*, $Na_2CO_3 + CaCl_2 = 2NaCl + CaCO_3$, *i. e.*, sodium carbonate and calcium chloride acting upon each other produce sodium chloride and calcium carbonate.

4. *Chemical Displacement.*—Where an element is displaced from a solution of its compound by another element that has a greater affinity for the other things contained in the solution, *i. e.*, iron dipped in a solution of copper sulphate displaces copper. $Fe + CuSO_4 = FeSO_4 + Cu$.

Q. 960. Illustrate (1) by elementary substances and (2) by compound substances, the statement that "chemical combination takes place most readily between those bodies which least resemble each other."—M. U. 1882; 1887.

Ans. (1) Hydrogen differs in many respects from oxygen; the former burns, the latter supports burning: when substances containing hydrogen and oxygen are decomposed by electricity, hydrogen appears at one pole of the battery and oxygen at the other. These two elements unite readily to form water.

(2) Caustic potash and sulphuric acid are different compounds and possess opposite properties; the former turns red litmus blue, the latter, blue litmus red; the former is the result of a metallic oxide dissolving in water, and the latter, is the result of a non-metallic oxide dissolving in water. Both of these readily unite to form potassium sulphate.

Thus, we see that combination takes place most readily between things which least resemble each other, be they elements or compounds.

Q. 961. Two elements A and B combine together in two different proportions by weight as follows:—A 42·86 and B 57·14; A 27·27 and B 72·13. Do these elements in these combinations obey the law of combination in multiple proportions? Give reasons for your answer.—M. U. 1886.

Ans. (1) A : B : : 42·86 : 57·14, *i. e.*, as 3 : 4 nearly

(2) A : B : : 27·27 : 72·13, *i. e.*, as 3 : 8 nearly.

In (1) 4 parts of B combine with three parts of A; and in (2) 8 parts of B combine with three parts of A. The proportions of the masses of B combining with the same mass of A are as 1 : 2 and are, therefore, very simple. Hence the law is obeyed. For, the law tells us that when two more elements unite in different proportions to form different compounds, the masses of the element combining with a constant mass of the rest bear a simple ratio to one another.

Questions for Exercise.

Q. 962. Common salt, sulphur trioxide, carbon dioxide, and metallic sodium dissolve in water; ammonia, chalk, and metallic zinc dissolve in dilute hydrochloric acid; sulphur dissolves in carbon-di-sulphide; state what in each case remains, on evaporating the solvent.—Lon. Mat. 1901.

Q. 963. Describe a method for the preparation of hydrogen from (*a*) sulphuric acid, (*b*) iron and water.
—Cal. U. 1902.

Q. 964. Describe exactly what takes place when carbon dioxide is passed through lime water until no further change takes place and the solution then boiled. What would happen, if after boiling a few drops of hydrochloric acid were added? If the acid had been added before boiling, what would have happened?—Lon. Mat. 1903.

Q. 965. Describe an experiment in support of the statement that matter is indestructible.—B. U. 1898.

Q. 966. Give two examples of each of the following processes:—(*a*) Combination; (*b*) decomposition; (*c*) displacement; (*d*) double decomposition; (*e*) neutralisation. Represent the changes by equations and indicate the necessary conditions for bringing them about.—Lon. Mat. 1899.

Q. 967. Explain the terms element, compound, mixture and state to which of these classes each of the following belongs:—Chalk, sea water, brass, glass, air, distilled water, graphite, sand, gunpowder. Give your reasons in each case.—L. U. 1903.

Q. 968. What weight of zinc and of sulphuric acid must be employed in order to obtain just enough hydrogen to combine with 1 lb. of chlorine?—B. U. 1898.

Q. 969. Define the terms atom, atomic weight, molecule and molecular weight. How may a solution of hydrogen chloride be prepared from common salt? By what properties can (*a*) ammonia gas, (*b*) sulphur dioxide, be clearly distinguished from hydrogen chloride?—Cal. U. 1901.

Q. 970. Describe simple experiments to prove the following:—(1) That chlorine has great chemical affinity for hydrogen; (2) that chlorine has no affinity for carbon, (3) that carbon has more affinity for oxygen than it has for hydrogen.—Pun. Ent. 1903.

Q. 971. Explain the meaning of the terms "combustible" and "supporter of combustion." Describe an experiment which shows at the same time that air can burn in coal gas and coal gas in air.—L. U. 1903.

Q. 972. Define acid, alkali, salt. Mention two examples of each. Complete the following equations:—

i. $Zn + H_2SO_4 =$ B. U. 1901.

ii. $KNO_3 + H_2SO_4 =$

iii. $CaCO_3 + 2\,HCl =$

Q. 973. Describe how the presence in the air of oxygen, nitrogen, carbon dioxide, and water vapour can be respectively detected, and how each of these constituents can be separated from the other three —L. U. 1903.

Q. 974. Mention some of the phenomena which accompany chemical changes. Describe an experiment to illustrate your answer.—M. U. 1896; 1901.

Q. 975. Explain with the help of a diagram the nature of a candle flame. How can you prove that water and carbonic acid gas are formed when a candle burns?—M. U. 1895.

Q. 976. Compare the process of breathing air with the burning of a candle. How may it be proved that the same substances are produced in both cases?—M. U. 1899.

Q. 977. What is given off, and what is left behind when coal is (1) completely burnt in an open grate and (2) heated strongly in a closed vessel provided with a delivery tube?—M. U. 1899.

Q. 978. You are required to prepare and to collect by displacement of air a glass cylinder full of hydrogen and another of carbonic acid gas. Make sketches, each drawing occupying one sheet of your answer paper, of the apparatus you would employ in preparing each gas.—M. U. 1899.

Q. 979. Describe how you would ascertain the qualitative composition of water.—M. U. 1899.

Q. 980. State the characteristics of a metal and of a non-metal respectively from the point of view of (*a*) a chemist, (*b*) a physicist. Illustrate your answer by taking the elements phosphorus and lead as examples given.—L. U. 1903.

Q. 981. You are provided with a number of jars of ammonia gas; describe how you would experimentally demonstrate (*a*) its combustibility in oxygen, (*b*) its solubility in water, (*c*) its alkaline properties, (*d*) whether it is heavier or lighter than air, and (*e*) that it contains hydrogen.—L.U. 1903.

Q. 982. State how the two varieties of phosphorus differ from each other, and describe how each variety is employed in the manufacture of matches.—M. U. 1897.

Q. 983. What non-metallic element can be separated from common salt, and how? Describe the properties of this element, and mention a chemical test by which its presence in common salt is proved.—M. U. 1895; Pun. Ent. 1900.

Q. 984. What is bleaching powder? What takes place when sulphuric acid is added to it? In what manner are the two substances mentioned used in the process of bleaching? —M. U. 1897.

Q. 985. A piece of iron when placed in a solution containing copper sulphate precipitates copper. Name the new compound which is formed during the interaction. Assuming that 20 grms. of copper have been precipitated, calculate the weight of (*a*) the copper sulphate which has been decomposed and of (*b*) the new compound which has been formed.—M. U. 1897.

H = 1, C = 12, O=16, S=32, Ca.=40, Fe = 56, Cu = 63.

Q. 986. A compound has the following percentage composition :—

Potassium	= 28·7
Hydrogen	= 0·8
Sulphur	= 23·5
Oxygen	= 47·0
	100·0

—M. U. 1899.

What is its formula and name?

[K = 39. S = 32, O = 16.]

Q. 987. Calculate the weight in grammes of zinc which must be dissolved in H_2SO_4 in order to obtain sufficient hydrogen to yield on burning, 10 grammes of water.

—M. U. 1897.

Q. 988. Give the names and formulæ of four different compounds of calcium which occur in nature. How would you prepare from any one of them (*a*) lime, (*b*) calcium nitrate.—L. U. 1903, June.

Q. 989. Explain the chemical changes which take place when the following are brought together: (*a*) Lime water and carbon dioxide; (*b*) hydrogen and heated black oxide of copper; (*c*) sodium chloride and sulphuric acid; (*d*) solution of silver nitrate and of sodium chloride; (*e*) solution of copper sulphate and a clean piece of iron.—B. U. 1898.

Q. 990. What is meant by the combining weight of an element? When several compounds are formed by the same two elements, in what proportion do these elements exist in the compounds? Explain your answer by means of examples.—M. U. 1894.

Q. 991. Describe a method of preparation, the properties and the uses of:—Lime water, calcium chloride, soda, chlorine, chalk.—M. U. 1896.

Q. 992. Nitric acid is an oxidising agent. Describe any experiment you have seen performed which illustrates its oxidising action. How would you prepare the acid from saltpetre? Write an equation for the chemical change by which it is produced.—M. U. 1898.

Q. 993. Describe what you have seen to take place when a burning candle is brought into jars containing the following gases:—Nitrogen, oxygen, hydrogen, chlorine, carbon dioxide. Explain the cause of the effects observed in each case.—M. U. 1898.

Q. 994. Describe the method of preparation, and state the composition and properties of the following substances:—Quicklime, slaked lime, silver nitrate.—M. U. 1897.

Q. 995. Mention (without going into details) the experiments you have seen performed to prove:—(1) that oxygen is necessary for the combustion of a candle; (2) that

carbonic acid gas and water are produced when a candle burns ; (3) that the carbonic acid and water weigh more than the burnt candle.—M. U. 1900.

Q. 996. Make a sketch occupying one sheet of your answer paper, of the apparatus you have seen used to prepare nitric acid. (2) By what properties may this acid be distinguished from sulphuric acid ?—M. U. 1900.

Q 997. Describe and explain the various methods with which you are acquainted by means of which air can be deprived of its oxygen.—L. U. 1901.

Q. 998. Describe all the changes which occur and name all the compounds formed when—

(1) black oxide of copper is heated in a stream of hydrogen, (2) a piece of *a* silver coin is warmed with nitric acid, (3) water is poured over quicklime, (4) powdered antimony is thrown into chlorine.—M. U. 1902.

Q. 999. (1) What is lime-water, and how is it made ?

(2) What chemical and physical changes take place when carbon dioxide is passed through lime-water ?—M. U. 1899.

Q. 1000. State without giving experimental details :—(1) How the volume and the weight of oxygen which combines with unit volume and weight of hydrogen to form water can be ascertained ; (2) how, from these numbers, the relative densities of the two gases may be calculated.—M.U. 1897.

Q. 1001. (1) Name all the substances produced when sulphuric acid is added to each of the following :—Common salt, magnesia, iron, chalk, saltpetre, caustic potash.

(2) Write equations to represent any two of these changes—M. U. 1900.

Q. 1002. What weight of sulphur is required to furnish 16 grams. of SO_2? [At. wts. O = 16, S = 32.]—C. P. 1899.

Q. 1003. What experiments would you make to prove that a given liquid was pure water.

Q. 1004. Describe experiments which could be performed in order to demonstrate the points of difference between an aqueous solution of ammonia and of caustic potash respectively.—L. U. 1901, Jan.

Q. 1005. For what purposes are chemical equations employed, and what information do they convey?
—M. U. 1888.—Pun. Ent. 1900.

Q. 1006. What is the meaning of the word oxygen and why was it given to the element? Point out in what respects the name is suitable still, as well as those circumstances which make it unsuitable.—L. U. 1903, June.

Q. 1007. State (1) four metals that do not tarnish in air. (2) Four that undergo chemical changes by exposure. (3) Four elements that decompose water only at high temperatures. (4) The chief ores of iron.

Q. 1008. State what happens when—

(1) Chlorine is passed into ammonia.

(2) Chlorine is passed into lime-water.

(3) Sulphuric acid is poured on (*a*) sodium chloride, (*b*) a mixture of sodium chloride, manganese dioxide, (*c*) a mixture of potassium chlorate and sugar.

(4) Pure sulphuric acid is poured on pure zinc.

(5) Sodium amalgam is poured into water.

(6) Nitric acid is poured on copper turnings.

(7) Ammonium nitrate is heated.

(8) Ammonium chloride is rubbed with slaked lime.

Q. 1009. (*a*) In connection with any six of the experiments on oxygen, give the required information in the following form :

Experiments seen.	What was observed in connection with each.	What was learnt from each experiment.

(*b*) Calculate the quantity of red oxide of mercury which will give out oxygen enough to combine with all the hydrogen obtained by the action of sulphuric acid on five pounds of zinc.

[H = 1 ; S = 32 ; O = 16 ; Zn = 65 ; Hg = 200.]

Q. 1010. State exactly what you would do in order to show that chalk is insoluble in water, but is dissolved by carbonic acid—L. U. 1899, June.

Q. 1011. What are the chief differences in proportion between the oxygen combined in water, and the oxygen dissolved in water?—L. U. 1899, June.

Q. 1012 Chlorine is said to act as an oxidising agent ; give examples and state the condition necessary.—L.U. June.

Q. 1013. What are litmus, pewter, plumber's solder, galvanized iron, lime, calomel, chrome yellow, plaster of Paris, black lead, red lead, heavy-spar and brimstone?

Q. 1014. Arrange the metals which you have studied in the descending order of their specific gravity and state (1) which of them float in water, (2) which of them burn in the

air when heated, (3) which of them can decompose water and (4) which of them are not acted upon by dilute sulphuric acid.

Q. 1015. What is an oxidising agent and how does it differ from a reducing one? Give two examples of each and explain their action.

Q. 1016. State the colour and *name* the constituents of (1) potassium ferrocyanide, (2) alum, (3) lead acetate, (4) potassium chromate, (5) galena, and (6) blende.

Q. 1017. Give examples of different kinds of chemical action.

A piece of iron, thrown into a solution of bluestone, is completely dissolved displacing 450 grammes of copper. Calculate the weight of iron.

[Cu = 63, Fe = 56, S = 32, O = 16.]

Q. 1018. State the points of difference between the following substances and one important use of each :—

(1) Gypsum and plaster of Paris.
(2) Washing soda and sodium bi-carbonate.
(3) Lead and black lead.

Q. 1019. Explain how you would distinguish *lead* from *tin*. Mention five of the compounds of lead and state about each, its colour, common name, and composition.

Q. 1020. Some bodies when exposed to air increase in weight while others lose weight ; mention three instances of each kind and explain whether the application of heat during the exposure affects the changes in any way.

How would you utilize some one of these changes in order to investigate the composition of the air.—L. U. 1903.

Q. 1021. Explain the difference between an algebraical and a chemical equation. State all the facts that you can learn from a chemical equation. Give equations to represent the reactions in the following cases:— (1) Sodium carbonate is added to hard gypsum water; (2) potassium chlorate is heated till the oxygen in it is expelled; (3) an iron wire is placed in a solution of copper sulphate; (4) a piece of phosphorus is burnt and the fumes allowed to dissolve in water; (5) hydrochloric acid is poured on marble.

Q. 1022. Describe the physical and the chemical changes that take place when a candle burns. Draw a figure to show what appears on a piece of white paper when it is carefully pressed over a candle flame and taken out. How do you account for its formation?

Q. 1023. Name each of the following:—

(1) the strongest metal, (2) the most malleable metal, (3) the hardest solid, (4) the best insulator, (5) the substance of the highest specific heat, (6) a bad conductor of heat, (7) a good conductor of electricity, (8) the best cell for electric bells.—Pun. Ent. 1901.

Q. 1024. What principal substances are produced, and how may they be separated, when an alkali and fat are boiled together?—Pun. Ent. 1904.

Q. 1025. Describe the physical properties of cast iron, wrought iron, and steel, and give the test for detecting iron salts in solution.—Pun. Ent. 1904.

Q. 1026. Name the chief alloys of copper and give their composition. How may copper be obtained from its oxide?—Pun. Ent. 1904.

Q. 1027. Briefly describe the important properties of the following metals :—

Aluminum, magnesium, lead, antimony, zinc. Also mention the uses of each metal.—Pun. Ent. 1901; 1902.

Q. 1028. Distinguish the elements from the compounds in the following list of substances :—Sand, lime, diamond, glass, chalk, plumbago, iodine nitre, common salt, galena, oil of vitriol Name the elements present in each compound.—Pun. Ent. 1901.

Q. 1029. Three glasses contain solutions of compounds of lead, iron, and silver respectively. How would you find out which is which.—Pun. Ent. 1901.

Q. 1030. Chemical combination is said to take place in certain definite proportions. Explain this, and give an example. What is meant by a chemical equation.—Pun. Ent. 1901.

Q. 1031. Sketch the blast furnace and explain how iron is extracted from its ores. Name the three varieties of iron as well as its principal ores. What is meant by the terms *tempering* and *puddling*.—All. U. 1902.

Q. 1032. Four test tubes containing weak solutions of silver nitrate, copper sulphate, potassium chromate, and iron chloride, respectively, are given to you. How would you proceed to test for the metal present in each salt?
—Pun. Ent. 1902.

Q. 1033. How does lead occur in nature? How is it extracted? Name its chief properties and uses.
—Pun. Ent. 1900.

Q. 1034. Give the chemical name and constituent elements of the following compounds :—Epsoms salts, lime,

Glauber's salt, alkali, soda, alumina, galena, bluestone, and green vitriol.—Pun. Ent. 1900.

Q. 1035. How can you show experimentally that a little copper is present in a sovereign?—Pun. Ent. 1900.

Q. 1036. What weights of nitre and sulphuric acid will be required for the preparation of five lbs. of nitric acid? [K = 39; N 214; S = 32; O = 16]—Pun. Ent. 1900.

Q. 1037. Explain the fact, that although pure zinc remains unaffected in ditute sulphuric acid, ordinary zinc is rapidly dissolved. Explain also how ordinary zinc may be treated so as to be used economically in such cells as Groves'. —Lon. Mat. 1902

Q. 1038. What is coal? What evidence have we of its origin? How does it differ from charcoal? What happens if it is heated out of contact with the air?

Q. 1039. Compare the candle flame with that of a Bunsen burner (*a*) when the air is admitted below and (*b*) when the air is shut off. - Lon. Mat. 1903, June.

Q. 1040. Write the names and describe the appearances of the substances produced when dilute sulphuric acid and hydrochloric acids respectively, are mixed with soda and lime, respectively, and the water evaporated away.—L. U. 1899.

Q. 1041. Describe the changes which occur, and name the products formed when a piece of potassium is thrown upon water. What new property does the water acquire in consequence of this action. Mention two ways by which this property can be recognised.—M. U. 1892.

Q. 1042. How can it be shown that when a candle burns he carbon and the hydrogen of the candle undergo oxida-

tion? The breathing of animals is called an act of oxidation; explain this.—M. U. 1902.

Q. 1043. How can river or well water be freed from (*a*) suspended, and (*b*) dissolved impurities? Draw a diagram of any apparatus which may be used for the latter purpose; and state how you could distinguish pure water from river or well water.—M. U. 1901.; B. U. 1900.

Q. 1044. What are the composition, the properties, and the uses of each of the following substances, and how is each prepared:—Plate glass, cast iron, hard soap, calcium chloride, chalk?—M. U. 1901.

Q. 1045. (1) Make a sketch, occupying one sheet of your answer paper, of the apparatus you have seen used to show that water is produced when hydrogen burns in the air. —M. U. 1903.

Q. 1046. Describe the appearance, properties and chief uses of (*a*) washing soda, (*b*) baking soda, (*c*) caustic soda. How would you prepare each of the two former from the last? How is caustic soda made on a large scale?—L. U. 1903.

Q. 1047. You are given two bottles one containing air and the other hydrogen; how would you show which gas is the lighter of the two? Aid your description by drawings. —M. U. 1901.

Q. 1048. (1) What is meant by the combining weight of an element? (2) When hydrogen is passed over an excess of heated oxide of copper, the oxide loses 60 grammes in weight and 67·5 grammes of water are formed. From these data calculate the proportion by weight of oxygen to hydrogen in water. (3) State whether the numbers so obtained are the same as the combining weights of these elements: and, if not, give reasons for the difference.—M. U. 1901.

Q. 1049. (1) Fifty-three grammes of bluestone are dissolved in water; calculate the least weight of iron required in order to throw down all the copper present in the solution. (2) How can you tell when all the copper has been thrown down?—M. U. [H = 1; O = 16; S = 32; Fe = 56; Cu = 63.]

Q. 1050. Describe and explain what is seen to take place in each of the following cases:—

(*a*) Nitric acid is poured on copper turnings;

(*b*) Dilute sulphuric acid is warmed with iron filings,

(*c*) Soap is dissolved in water containing gypsum in solution;

(*d*) A lighted candle is put into a jar of chlorine;

(*e*) Magnesium ribbon is burnt in air.—M. U. 1901.

Q. 1051. A natural water is found to give a white precipitate (*a*) on boiling, (*b*) on the addition of a solution of silver nitrate, (*c*) on the addition of a solution of barium chloride; what inferences would you draw from the behaviour and how would you test their accuracy.—L. U. 1900.

Q. 1052. (1) Describe (*a*) the appearance, (*b*) the properties, of the two common varieties of phosphorus. (2) What grounds are there for asserting that these two substances are (*a*) elementary bodies, (*b*) one and the same element?
—M. U. 1903; All. U. 1902; Pun. Ent. 1901.

Q. 1053. Describe the experiments by which it can be shown that—(1) Chlorine has bleaching properties. (2) Vegetable matter contains carbon. (3) Metals become heavier by oxidation.

Mention, without describing, the experiments which you have seen performed to show—

(4) the decomposition of water,

(5) the formation of water;

and in each case state what the experiment teaches as to the composition of water.

Q. 1054. When hydrogen is passed over heated copper oxide, it displaces the copper and forms hydrogen oxide. Mention three other reactions in which an element is obtained by displacement by another element. Write equations for two of these reactions.—M. U. 1903.

Q. 1055. (*a*) Explain the terms hardness and softness as applied to water.

(*b*) What are the different kinds of hardness and how are they caused?

(*c*) What kind of hardness can be removed and how?

(*d*) Describe clearly the method of testing a water in order to ascertain whether it is hard or soft.—M. U. 1902.

Q. 1056. Gunpowder is made by mixing together charcoal, sulphur and saltpetre; describe fully how you would propose to obtain each of these ingredients in a state of purity from a specimen of the powder.—L. U. 1900, June.

Q. 1057. Give the different zones in the flame of an ordinary candle; and explain what happens in each.—L. U. 1884.

Q. 1058. What is 'fire damp,' and under what circumstances does it cause an explosion? Why are people suffocated by the air in a coal mine immediately after such an explosion? —M. U. 1902.

Q. 1059. Chemical changes are always accompanied by changes of other descriptions. Give some illustrations of these latter changes, and mention the chemical changes which produce them.—M. U. 1887.

Q. 1060. State what you would *see*, if the following experiments were performed before you, and write the equatio

enting the reactions which would occur ; 1. sulphuric acid is poured upon a piece of chalk ; 2. sulphuric acid is poured over some pieces of granulated zinc ; 3. a clean cut piece of sodium is thrown upon water.—M. U. 1900.

Q. 1061. The metallic or non-metallic nature of certain elements can be recognised, you are told by their appearance. What are the properties referred to, and how does a knowledge of them enable you to decide whether an element is a metal or a non-metal ?—M. U. 1887 : Lon. Mat. 1902, Sept.

Q. 1062. Give some illustrations of the statement that chemical combination takes place most readily between bodies which least resemble one another.—M. U. 1882.

Q. 1063 Describe the preparation properties and composition of coal gas. How would you prove experimentally that it contains both carbon and hydrogen ?—Pun. Ent. 1903.

Q. 1064 Explain the terms crystallisation, deliquescence, saturation, solution, suspension ; give two illustrations of each.—Pun Ent. 1903.

Q. 1065. Describe as many methods as you know of softening 'hard water'. Explain clearly how *fur* is formed in a kettle.—Pun. Ent. 1903.

Q. 1066. State the chief characteristics of an acid. Also define a base, a salt, a hydroxide, and an alkali.
—Pun. Ent. 1903.

Q. 1067. How can it be shown that common salt is a compound of chlorine ? What is the action of perfectly dry chlorine over organic coloring matter ?—Pun. Ent. 1904.

Q. 1068. What do you understand by the terms (*a*) organic chemistry and inorganic chemistry, (*b*) metals and non-metals.—Pun. Ent. 1904.

Q. 1069. What are the chief characteristics of chemical union? Distinguish between a chemical compound and a mechanical mixture. Is air a compound or a mixture. Give reasons for your answer.—Pun. Ent. 1904.

Q. 1070. Describe, as fully as you can, the action of strong and dilute sulphuric acids separately on each of the following substances:—(1) sodium carbonate; (2) iron filings; (3) marble; (4) caustic soda; (5) zinc. What new substances are formed in each case?—Pun. Ent. 1903.

Q. 1071. Describe simple experiments to illustrate the chief properties of hydrogen. Why is it that strong sulphuric acid has almost no action upon zinc or iron?
—Pun. Ent.

Q. 1072. How is nitric acid prepared? State its properties and uses and tests? How would you distinguish it (1) from sulphuric acid, (2) hydrochloric acid?
—All. U. 1902; Pun. Ent. 1904.

Q. 1073. What weight of oxygen can be obtained by heating twenty seers of potassium chlorate? [K : Cl : O : : 39 : 35·5 : 16]—Pun. Ent. 1904.

Q. 1074. How can you show, by means of experiments, the hollowness of a flame?—Pun. Ent.

Q. 1075. Describe the preparation and properties of two (*and only two*) of the following:—Chlorine, sulphur dioxide, ammonia. Make neat sketches of the apparatus you would use for their preparation.—Pun. Ent. 1901.

Q. 1076. What do we mean when we say that hydrogen is an inflammable gas? Is it so in all circumstances? Explain the term supporter of combustion.—Pun. Ent. 1903

Q. 1077. How is the composition of water by weight determined? Give the details of the process. What weight

of hydrogen and of oxygen is contained in 50 lbs. of pure water ?—Pun. Ent. 1901.

Q. 1078. Describe some experiments showing the structure of a candle flame.—Pun. Ent., 1901.

Q. 1079. Explain the action of Davy's safety lamp.—Pun. Ent., 1901.

Q. 1080. You are given some chalk and hydrochloric acid ; name the substances you can prepare from them, and describe their properties.—All. U. 1902.

Q. 1081. Describe any method you know of preparing sodium carbonate from common salt.—All. U. 1902.

Q. 1082. The following substances are separately treated with sulphuric acid :—copper, zinc, potassium chlorate, sodium carbonate and manganese dioxide. State with equations the reactions that take place.—All. U. 1902.

Q. 1083. Describe briefly five experiments which you have seen performed with hydrogen gas, and mention what each experiment is meant to show.—All. Mat., 1902.

Q. 1084. (*a*) How is ammonia gas prepared ? Of what does the liquid called liquor ammonia consist ?

(*b*) Mention the chief properties of ammonia gas. What are its tests ?—All. Mat., 1902.

Q. 1085. Describe the use made in the laboratory of a mouth blowpipe and a Bunsen burner. If the holes in the bottom ring of a Bunsen burner be stopped, how would it effect the flame and why ?—Pun. Ent. 1902.

Q. 1086. State clearly all the points of difference and of resemblance between *coal* and *charcoal*. A piece of shale from

coal measures has an imprint of leaves, etc., as in fig. 131. What do you learn from it about the origin of coal.

Fig. 131.

Q. 1087. Give four methods of obtaining oxygen representing the chemical changes which take place by means of equations and describe experiments illustrating the properties of this gas. State why manganese dioxide is mixed with potassium chlorate.—B. U. 1896.

Q. 1088. What weight of mercuric oxide must be employed in order to obtain just enough oxygen to combine with one lb. of hydrogen ; [H = 1 ; O = 16 ; Hg = 200.]

—B. U. 1896.

Q. 1089. Describe and explain what is seen in the following cases :—

(1) Nitric acid is poured on copper.

(2) Zinc is suspended in a solution of lead acetate.

(3) Soap solution is mixed with water containing gypsum in solution.

(4) A wet green paper, with printed letters, pencil marks, and letters written in ink, is put into a jar of chlorine.

(5) Sulphuric acid is poured over rock salt.

(6) A jar of ammonia is inverted over a basin containing blue litmus solution.

(7) Potassium chlorate is strongly heated in a tube.

(8) Oil of vitriol is poured over caustic soda.

Q. 1090. State the names and formulæ of the compounds formed when phosphorus is burnt in any two gases that you studied. What happens when the element is heated strongly in a vacuum?

Q. 1091. What is electrolysis? Suppose you weigh the substances obtained by submitting water to electrolysis, which weighs more and by how much?

Q. 1092. Mention eight varieties of carbon, their characteristic properties and their important practical applications.

Q. 1093. What is the effect of heating chalk, rock crystal, a mixture of hydrogen and oxygen, carbon and sulphur in air? Name and give the formula of each substance produced.—Lon. Mat. 1900 Jan.

Q. 1094. What are the principal ingredients used in the manufacture of (1) safety matches, (2) common lucifer matches? Explain the chemical action in each, when combustion takes place.—B. U. 1900.

Q. 1095. Give the formulæ for the sulphates of copper, lead, iron, and zinc. Describe the appearance of these salts

and indicate how they could be obtained from the metals respectively.—Lon. Mat. 1903.

Q. 1096. Name some important compounds which could be formed by combining in different proportions, any two or more of the following elements:—(N, O, H, C.)
—B. U. 1900.

Q. 1097. Sketch the apparatus you would employ for the preparation of chlorine and describe three experiments illustrating its properties.—Pun. Ent. 1900; Lon. Mat. 1901.

Q. 1098. What is the action of nitric acid on (*a*) silver, (*b*) copper and (*c*) gold.—Cal. U. 1092.

Q. 1099. What is left behind as gas when phosphorus burns in a closed vessel? What properties has it? Has it been made to combine with oxygen? and if so, how?
—Lon. Mat. 1901.

Q. 1100. Mention the allotropic varieties of carbon and briefly describe an experiment to demonstrate the identity of their derivation from the same element.—B. U. 1899.

Q. 1101. What elements are present in (*a*) steel, (*b*) bone, (*c*) china, (*d*) wood, (*e*) a six pence, (*f*) a sovereign, (*g*) a diamond.—Lon. Mat. 1902 June.

Q. 1102. Mention any substances used in the process of bleaching and explain the chemical changes that take place in the action.—B. U. 1899.

Q. 1103. What do you understand by the term allotropy? Compare the properties of allotropic forms of sulphur.
—Cal. U. 1902.

Q. 1104. Write down the action that takes place when each of the following acids acts upon (1) iron and (2) lead: sulphuric acid, nitric acid, hydrochloric acid.—B. U. 1899.

Q. 1105. What is formed when phosphorus burns in air? Can it be made to burn in any other gas? If so, in what?—Lon. Mat. 1901.

Q. 1106. If a liquid contains hydrochloric acid in it, how would you detect it? How could you get ammonia from its chloride?—B. U. 1898.

Q. 1107. How is iron extracted from its ores? Name and give the properties of several varieties of iron. Describe the process known as *tempering*.

—M. U. 1888; Pun. Ent. 1901, 1904.

Q. 1108. Manganese chloride is found on analysis to contain manganese 43·63 *p. c.* and chlorine 56·37 *p.c.* Calculate its simplest formula (Mn = 55, Cl = 35·5).—Lon. Mat. 1901 June.

Q. 1109. (*a*) Explain why sulphur is called a non-metal and potassium a metal. (*b*) Draw up a list of the most important non-metals and state opposite to each in parallel columns :—(1) how it occurs in nature ; (2) whether it occurs in more than one form, and if so, name the forms ; (3) whether it is inflammable in air, and if so, name the compounds formed when it burns—M. U. 1904.

PART III. PHYSICAL GEOGRAPHY, &c

SECTION I.—THE EARTH.

Q. 1110. Give three proofs of the spherical form of the earth.—M. U. 1898.

Ans. First Proof: The line around us at a distance where the earth and sky seem to meet, is always circular. This line is called the horizon. The greater the height we ascend, the larger does the horizon appear, but it always retains the circular form. These circular forms of the horizon prove the spherical form of the earth.

Second Proof: "The earth in its revolution round the sun sometimes comes between the sun and the moon. It then casts a shadow on the moon, so as to eclipse it; and as the shadow is always circular, the shape of the earth must be spherical."

Third Proof: "When a ship is sailing towards the land we see the top sail first, next the masts, and last of all the hull. The hull is at first hidden by the curved surface of the sea. If the earth were flat, we should see the hull first, because it is largest."

Fig. 132.

[Mars, Jupiter, Venus and other planets are all spherical. The earth is a planet. There is no reason why it should be an exception. Again, if the earth were flat all places on it ought to have the sunrise at the same time. But different places have the sunrise at different times.]

Fig. 133.

Q. 1111. (1) Prove that the earth is round like a ball, and (2) explain why the antipodes do not fall off from it. —Pun. Ent. 1904.

Ans. (1) Read the answer to Q⁴ (2). The antipodes are attracted by the earth as much as we are attracted by it. The earth attracts everything from its centre, A thing thrown high up into the air falls towards the earth. Hence, the antipodes do not fall off from the earth. Figure 133 enables you to realise this truth. Note A and B, in the figure ; also C and D.

Q. 1112. What are the two principal motions of the earth ? State two visible evidences of each.—M. Mat. 1898.

Ans. (1) *Motion of rotation upon its own axis.* This causes day and night. This is one evidence. The direction of the Trade Winds, instead of being due north or south, is north-east in the Northern Hemisphere and south-east in the Southern Hemisphere. This deflection of the Winds is due to the rotatory motion of the earth This is another evidence.

(2) *Motion of revolution round the sun* : One evidence of this is that the stars appear not to have the same positions throughout the year. This is one evidence of the revolution of the earth round the sun. For as

the earth moves in her orbit, the stars appear to change their positions. The stars are fixed. Therefore it is really the earth that moves on. Another evidence is the occurrence of the seasons.

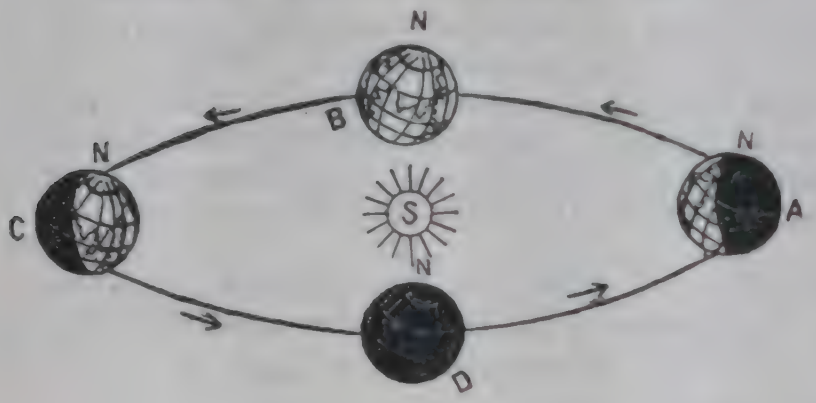

Fig. 134.

Q. 1113. Define poles, arctic circle, watershed, isthmus, and zones. Explain with the help of a diagram how there is one long night and one long day, each of six months' duration, at the poles.—Pun. Ent. 1900.

Ans.—Poles are the extremities of the axis of the earth. The axis of the earth is the imaginary line which passes through the centre of the earth and about which the earth rotates.

Arctic circle is the name given to the boundary of the North Frigid Zone and is at a distance of 23·5 from the North Pole.

Watershed is the name given to the ridge of land which separates the water that flows into two different river basins. River basin is the area drained by a river.

Isthmus is a narrow strip of land which connects two large bodies of land and separates two bodies of water.

Zones are the divisions into which the surface of the earth has been divided according to the apparent position of the sun in the course of the year. These zones are bounded by the parallels of latitude. These different zones receive different amounts of heat from the sun.

It is a well known fact that the axis of the earth is inclined to the plane of its revolution and is not at right angles to it. It is inclined about 23·5° or about one-fourth of a right angle. Hence, du-

ring the revolution of the earth round the sun the North Pole will be towards the sun for about half of its orbit, and the South Pole will be away from the sun. During its passage through the remaining half of the orbit the South Pole of the earth will be towards the sun and the North Pole will be turned away from the sun (Fig. 134). To go over the orbit, the earth takes one year. Hence, during its passage through half (*i. e.* for about 6 months) the North Pole will have perpetual sun light, *i.e.*, a day of six months and during the remaining six months the North Pole will have darkness, as it will be away from the sun, and the South Pole will have light.

Q. 1114. (i) What are the tropics? (ii) Name them. (iii) By what name is the belt of the earth included within them known? (4) What portions of India do not lie within this belt?—M. U. 1886.

Ans.—

(i) "The tropics are two circles drawn round the earth parallel to the equator at a distance of nearly $23\frac{1}{2}°$ on each side of it".

(ii) The Tropic of cancer; and the Tropic of Capricorn.

(iii) The Torrid Zone.

(iv) The United Provinces; the Frontier Province; Sindh; northern part of Rajputana; Cashmere; Assam; Nepaul; Bhutan; northern half of the Lower Provinces of Bengal.

[At all places situated on the northern tropic, called the Tropic of Cancer, the sun is vertical at noon on the 21st June. At all places on the southern tropic, called the Tropic of Capricorn, on the 21st December. At all places between these tropics, the sun is vertical on two days in each year. But at places beyond the tropics the sun is never vertical.]

Q. 1115. Explain the terms, latitude, longitude, meridian, parallels of latitude.

Ans.:—*Latitude* "is the distance of a place north or south of the equator and is measured in degrees." *Longitude* is "the distance east or west of a meridian chosen as the prime one". Greenwich meridian is almost universally accepted as the prime meridian.

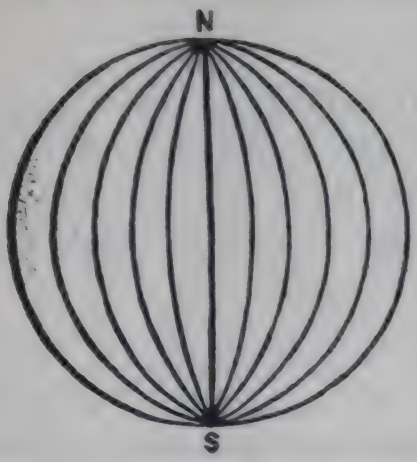

Fig. 135.

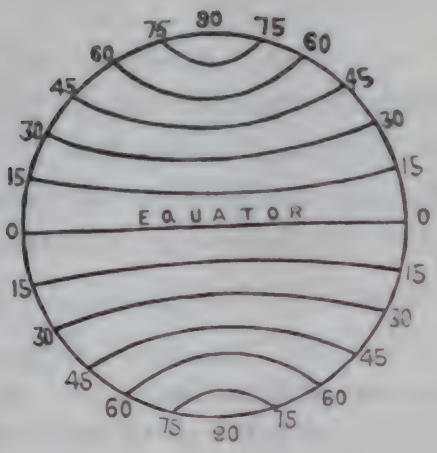

Fig. 136.

Meridian is the imaginary circle that passes round the earth through the poles, cutting the equator at right angles. Each place has its own meridian. (Fig. 135.) When the sun is exactly above the meridian of a place it is noon at that place.

Parallels of latitude are those imaginary lines drawn round the earth parallel to the equator above and below. (Fig. 136.) The exact position of any place on the earth's surface can be found out when its latitude and longitude are given.

Q. 1116. What do you understand by the following terms :—(1) East Longitude, (2) North Latitude, (3) West Longitude, (4) South Latitude.

Ans. (1 and 3.) The longitude of a place is its distance from the standard meridian. The meridian of Greenwich is chosen as the standard one. Hence *East Longitude* means a place to the east of Greenwich : *West Longitude* means a place west of Greenwich. *Melbourne* is 45° E. means (1) it is to the east of Greenwich, (2) and is separated from it by 45°. Quebec is 70° W. means (1) that it is to the west of Greenwich, and (2) that it is separated from it by 70°.

(2 and 4.) The latitude of a place is its distance from the equator. If the place is to the north of the equator it is known to be in the north latitude : if a place be to the south of the equator it is said to be in the south latitude. Pekin is 40° N. means that (1) Pekin is to the north of the equator, and (2) Pekin is at a distance of 40° from the equator. Similarly a town is 30° S. means (1) that it is to

the south of the equator, and (2) that it is separated by 30 degree from the equator.

Q. 1117. A ship is in Latitude 0° Long 0°. State as nearly as you can what part of the world she is in ? (2) A ship's Captain in the Bay of Bengal finds his longitude decreasing and his latitude increasing. Towards what point of the compass is he sailing.—M. U. 1901.

Ans. (1) On the western side of Africa in the Gulf of Guinea.

(2) Towards north-west. The reason is this. *Longitude* is measured from *Greenwich*. If the longitude decreases the Captain must be going towards Greenwich, *i. e.*, towards the West. Latitude is measured from the equator. Therefore if the latitude increases he must be going away from the equator *i. e.*, towards the north. Hence, the ship is sailing towards the *north-west*.

Q. 1118. Correct the following and give reasons for your correction :—The North Longitude of a place is 35° and its East Latitude, 42°. Mr. Hicks reached that place at 12 a.m.

Ans. Longitude is the distance of a place east or west from the standard meridian. Hence, it is wrong to speak of North Longitude or South Longitude.

Latitude is the distance of a place from the equator north or south of it. So, it is wrong to speak of East Latitude or West Latitude.

When the sun is on the meridian it is noon at that place. It is 12 Noon and not A. M. ; for A. M. means *ante meridian*, *i. e.*, before the sun has crossed the meridian. Before the sun has crossed the meridian it is not 12 Noon, but 11 or 10 A. M. as the case may be. " Mr. Hicks reached that place at 12 Noon."

Q. 1119. Name all the places through which the Equator passes.

Ans.—Equador, Columbia, Brazil, the Atlantic Ocean, the Galapagos, Lower Guinea, Central Africa, Victoria Nyanza, Albert Nyanza, Zanzibar, the Indian Ocean, Sumatra, Borneo, Celebes, and Molluccas.

Q. 1120. What is the name given to the parallel which is $23\frac{1}{2}°$ north of the Equator? Through what divisions of India does it pass?—M. U. 1895.

Ans.—The Tropic of Cancer: It passes through Upper Burma, Bengal, the Central Provinces, Gwalior, Rajputana and Kutch.

Q. 1121. Forty degrees north of the Equator a parallel of latitude is drawn on the Map of Europe passing through the middle of Portugal, and crossing over the Dardanelles into Asia. Mention the countries, islands, and seas it passes through.—M. U. 1881.

Ans.

Countries:—Portugal, Spain, Italy and Turkey.

Islands:—Minorca, Sardinia and the Archipelago.

Seas:—The Adriatic and the Mediterranean.

Q. 1122. Define the following terms:—Tropics, Isothermal lines, Delta, Llano, Landes, Jhils, Right bank of a river, Trade Wind.—M. U. 1891.

Ans. Tropics. Read Qn. 1114.

Isothermal lines are those (imaginary) lines on the surface of the earth passing through places of equal mean temperature.

Delta: "Where a river enters the sea, its current is checked and a large part of the sand and mud still in suspension is deposited.... this deposit accumulates so far that at last a tract of flat alluvial soil forms above the level of the sea and divides the stream." This is triangular in shape having the branches of the river on two sides and the sea on the third. The triangular tract of alluvial deposit at the mouth of a river is called *delta.*

Llano is the name given to grassy plains in South America.

Landes: Sandy waste in the south-west coast of France.

Jhils: Lit. a shallow lake: these are stagnant pools formed by the springs in the deserted channels of streams in Bengal.

The right bank of a river: That bank of the river to the right of a person who stands looking towards the mouth of the river.

Trade winds: See Qn. 449.

Q. 1123. Explain what is understood by 'the Solar System'?

Ans.—The sun and the numerous bodies that revolve round the sun constitute the Solar System. The bodies that revolve round the sun are given in order commencing from that which is nearest to the sun :—

Mercury, Venus, the Earth, Mars, the Asteroids, Jupiter.Saturn. Uranus, Neptune.

In the above list the Asteroids are the minor planets about 400 in number. The rest are all planets and revolve round the sun with their satellites or moons.

In addition to these there are numerous small bodies that revolve round the sun.

Q. 1124 Explain the phenomena of '*meteors*'. What are '*shooting stars*' and how do they differ from *aerolites*?

Ans. Innumerable small bodies revolve round the sun. When they come into contact with the atmosphere of the earth they become heated by friction and are made white hot. They then appear brightly in the sky and are called *meteors* or *shooting stars*. They are often consumed by the atmosphere of the earth. But occasionally they fall down to the earth and are then known as *aerolites*.

Q. 1125. The earth is nearer the sun in January than in June. (1) How can this be known? (2) Why is it colder in January than in June?

Ans. (1) A thing appears bigger to us when it is nearer and smaller when it is farther. The sun appears a little bigger in January than in June. This shows that the earth is nearer the sun in January.

(2) The North Pole of the earth is inclined towards the sun in June and the rays fall less slantingly over us in June than in January. Hence, we feel hotter in June than in January.

Q. 1126. What are the following :—Equinox, Equinoctial Line, Solstices and Ecliptic.

Ans.—*Equinoxes*—the time when the days and nights are of equal duration. This happens when the sun is exactly over head at the equator at noon. There are two equinoxes, i. e., twice during the course of the year places on the earth's surface will have equal nights and days. One is called the vernal or spring equinox (March 21) and the other is the autumnal equinox (Sep. 22).

Equinoctical Line is the name given to the equator on account of equal length of the nights and days on all parts of the equator.

Solstices: On two days in the year the sun appears over head in all places in the tropics. These are known as the solstices. The bounding circles of the tropics are the Tropic of Cancer and the Tropic of Capricorn. At all places on the Tropic of Cancer the sun is vertical at noon on the 21st of June; and at all places on the Tropic of Capricorn the sun is over head at noon on the 22nd of December. Thus we have two solstices. The former is *our* summer solstice, and the latter, the winter solstice.

Ecliptic is the vast circle which the sun appears to make in the heavens throughout the year. The orbit of the earth is in the same plane as the ecliptic. It is so called because eclipses always take place only in this plane.

Q. 1127. What is a degree (in angular measurement)? How is it denoted? Why is it wrong to say that the axis of the earth is inclined to the plane of its orbit by 23·5°.

Ans.—'Degree' is the word used in the measurement of angles and denotes one-ninetieth of a right angle. It is denoted by a small zero placed above, to the right of the number denoting degrees, e.g., 45° means forty-five degrees.

The earth is not inclined to the plane of its orbit by 23½° The inclination of the earth's axis to the perpendicular to the plane of its orbit is 23·5°. The inclination of the earth to the plane of its orbit is (90—23·5)=66·5°.

Q. 1128. Explain, giving reasons, why it is wrong to say that (1) the cause of the seasons is nothing more than the revolution of the earth round the sun; (2) the earth is flat at the top and the bottom.

Ans.—(1) The cause of the seasons is not simply the revolution of the earth round the sun. It is due to two causes of which the revolution of the earth round the sun is one. The other is the in-

clination of the earth to the plane of its orbit. In one part of its orbit the Northern Pole will be inclined towards the sun. Then, it is summer to that part of the earth, i.e., Northern Hemisphere.

In another part of its orbit the Southern Pole will be inclined towards the sun. Then, it is summer in the Southern Hemisphere and winter in the other.

(2) There is no such thing as top or bottom to the earth. It ought to be stated that the earth is flattened at the poles.

Q. 1129. Explain clearly why there is not an alternation of equal days and nights all the year round in Madras.
—M. U. 1901. R.

Ans.—If the axis of the earth were perpendicular to the plane of revolution then all parts of the surface of the earth would be equally exposed to the sun throughout the year and Madras would have had equal nights and days throughout the year. But it is not. The axis is inclined to the plane of revolution and hence the difference in the lengths of nights and days throughout the year.

SECTION II.
The Land.

Q. 1130. How would you explain the presence of sea shells on the tops of some mountains and of the fossil remains of animals at a considerable depth under ground?—All. U. '02.

Ans.—There are reasons to believe that forces are at work in the interior of the earth which make certain parts of the earth rise above their former level, or sink below, as the case may be. "It is certain that the greater part of the present land, at one time or another, has been covered by the sea." The part of land raised by the forces referred to above, no longer contains water; but the sea-shells &c. remain there to remind us of the nature of that land. It is thus that the sea-shells which are to be found only in the sea happen to be found even on the tops of some mountains.

The forces mentioned above may sometimes cause the sinking of the earth with its animal and vegetable life. These, in course of time, become petrified and will be known as fossils. The fossils tell us the nature of animal and vegetable life in that part of earth at one

time. Thus, when a well was sunk in *Fort William* at Calcutta at a depth of 350 feet, 'part of the bony shell of a mud tortoise' was found.

Q. 1131. What are the following :—

The Eastern Hemisphere, the Western Hemisphere, the Northern Hemisphere, the Southern Hemisphere, the Land Hemisphere, and the Water Hemisphere.

Ans.—The *Eastern Hemisphere* is that part of the earth which contains the old world. The *Western Hemisphere* is that part of the earth which contains the new world.

The *Northern Hemisphere* is that part of the earth to the north of the equator. The *Southern Hemisphere* is that part of the earth to the south of the equator.

If the globe be divided in such a way that London may be the centre of one half and New Zealand may be the centre of the other half, there will be two hemispheres. That hemisphere which has London as the centre will contain almost all the land on the surface of the earth and is called the '*Land Hemisphere*'. The other contains almost all the watery part of the earth and is called the *Water Hemisphere.*

Q. 1132. What are volcanoes ? Trace their distribution on the earth's surface. What other proofs have we besides volcanoes, of the internal heat of the earth ?—Pun. Ent. 1900.

Ans.—Volcanoes are conical hills formed of erupted matter, and having at the top a cup-shaped cavity, termed the crater, from which a tube or pipe passes downward into the heated interior. —Thornton.

or

A volcano is the orifice or opening of a vent or channel, which communicates with the interior of the earth ; and through which heated water and steam, various gases and stony matters frequently liquefied by heat are ejected continuously or, in some case, at long intervals—Blanford.

Other proofs of the internal heat of the earth :—(1) The deeper we descend into the earth, the higher will be the temperature. (2) There are springs of hot water that gush out in different parts of the earth, as the one at Gangutri, at the source of the Ganges.

The distribution of volcanoes on the earth's surface:—There are about two hundred active volcanoes at present. These seem to fol-

low certain directions. Two important lines may be noticed. One in the Pacific Ocean and the other in the Atlantic Ocean. They are found in all regions of the earth's surface. They are, however, more numerous in the Torrid Zone. There are more than one hundred of the active volcanoes on the coast lands or islands of the Indian and Pacific Oceans.

The Pacific Coast :—Commencing from the East Coast we have a line of volcanoes passing through the *Andes*, *Central* America, and the West Coast of North America.

This line passes through the Aleutian isles to Kamschatka

The West Pacific :—Kamschatka contains 12, Keurile isles 10, and Japanese island over ten.

There are volcanoes also in Formosa, Philippine islands, and the Malay Archipelago. In the Malay Archipelago the volcanic line appears to be divided into two branches. The eastern side of the Bay of Bengal has one branch passing over it, while the other passes south-east through Celebes, New Guinea and New Hebrides. This line continues to New Zealand, Mount Erebus and Mount Terror in Antarctica.

In the Atlantic Ocean :—A volcanic line passes down the eastern side of the Atlantic from Iceland through (Faroe Islands, and west of Scotland, both of which have now extinct volcanoes) Azores, Canaries, and Cape Verde Island east of Africa. "This line appears to be connected with a great submarine ridge that runs down the middle of the Atlantic. One branch from this passes into the West Indies where there are six active volcanoes, while another branch passes into the Mediterranean."

Q. 1133. (*a*) Define "peninsula". In what direction do peninsulas generally stretch ? Name the exceptions and give their locality.—(*b*) What is an island ? When a number of islands are grouped together, what name is given to them ? Give an example and state its geographical position. (*c*) Capes are sometimes called by other names. Illustrate this by three examples : one from Norway, another from England and a third from Ireland. —M. U. 1883.

Ans - Peninsula is a piece of land which is almost an island. It is surrounded by water to a great extent but not completely. Their general direction of stretching is southwards. The

exceptions are (1) Asia Minor in Asia which stretches north-west (2) Jutland in Europe which stretches northwards; and (3) Alaska in Canada which stretches north-west. (*b*) Island is a piece of land which is completely surrounded by water. A group of islands goes by the name of *archipelago*, *e. g.*, The Malaya archipelago to the south-east of Asia.

(*c*)

Other names for capes.	Examples.
Naze.	The Naze (Norway).
Point.	The Lizard Point (England).
Head.	Malin Head (Ireland).

Q. 1134. "The volcanoes seem to follow certain defined lines as will be seen on reference to a map." State clearly what these lines are and what the probable explanation of fact may be.

Ans.—Read the answer to Q. 1132. The probable explanation of fact is that the volcanoes "occur on the lines of fissures in the earth's crust; these lines of fissures are indicated by the arrangement of these volcanoes.

Q. 1135. Africa resembles Australia in some important points. Mention three of these.

Ans.—(1) The coast lines of both are regular and the interior of both countries is a desert.

(2) In both countries the principal ranges of mountains are on the East Coast and these cause much rain on the East Coast,

(3) Both the continents have Coral islands on the East Coast.

Q. 1136. "Volcanoes are burning mountains". Explain clearly why this definition is wrong.

Ans.—First of all a volcano is not necessarily a *mountain* and secondly, it is not a *burning* mountain. It is simply an opening of a channel "which communicates with the interior of the earth and through which heated water, steam, various gases, and melted stony matter are thrown out in some cases continually and in others, at intervals"

Q. 1137. Large plains with peculiar characteristics are known by distinct names in different parts of the world. Give the names, situations and characteristics of six such plains. —M. U. 1887.

Ans :—

Names.	Situations.	Characteristics.
Llanos ..	North America..	Grassy plains.
Selvas ..	South America...	Grassy plains.
Steppes ..	Russia ..	Treeless plains.
Savannahs' ..	North America..	Grassy plains.
Prairies ..	South America..	Grassy plains.
Tundras ..	Siberia ..	Flat marshy treeless plains frozen hard in winter.
Pampas ..	South America.	Vast treeless plains.
Karoos ..	South Africa ..	Large tracts of clayey tableland. These rise like terraces towards the interior.
Llandes ..	South-west of France	Sandy plains.
Fens ..	England ..	Lowlying and swampy.
Heaths, Moors ..	West Europe ..	Plains.
Puszta ..	Hungary ..	Plain.

N. B.—The first six may be given in answer to question.

Q. 1138. What are earthquakes? Where do they generally occur? What are their effects? Give examples.

Ans.—"An earthquake is a trembling of the ground, a kind of molecular wave or vibration, propagated through the solid earth" in every direction from the centre of the disturbance. In volcanic regions earthquakes generally occur. The effects of the earthquakes differ according to the nature of the earthquakes. In some cases the waves may be so slight as to be just perceptible. Great earthquakes are very destructive to buildings which are thrown down in ruins. Sometimes earthquakes raise certain parts of the land or depress other parts of it permanently. Sometimes they cause fissures in the earth. The great earthquake of Lisbon in 1755 was one of the most destructive. 'A sound like that of thunder was heard underground, and immediately afterwards a violent shock threw down the greater part of the city. In the course of ten minutes sixty thousand persons perished." The earthquake of India that occurred this year (1905) was also one of the most destructive, and numerous lives and buildings were lost in the Kangra Valley (Northern India).

Q. 1139. Write notes describing the following and stating clearly the situation of each:—(1) The Salt Range; (2) The Sunderbans; (3) The Palaghat Gap; (4) The Cachar Valley; (5) The Konkan; (6) The Tarai; (7) The Sambar Lake; (8) The Gersoppa Falls; (9) The Coromandel; (10) The Cauvery Delta. —M. U. 1899 R.

Ans. (1) *The Salt range:* This is so called from the beds of salt which it contains. It stretches across the Indus, eastward to the Jhelum.

(2) *The Sunderbans:* Situated in the delta of the Ganges; intersected by numerous salt rivers and creeks. Formed by the deposits of the earth washed down by the Ganges during its periodical inundations; very unhealthy; abound with wild beasts.

(3) *The Palaghat Gap:* This is in the Western ghauts. But for this, the Western ghauts would be perfectly continuous. Through this gap the South West monsoon passes and causes rain fall in the Eastern side of the ghauts also to a certain extent. Palaghat lies in this gap.

(4) The Cachar Valley:—In Assam; East of Sylhet: is noted for its tea plantations.

(5) The Konkan :—A Division in Bombay Presidency. Northern Konkan (Thana), lies along the coast north of Bombay. Southern Konkan (Ratnagiri) lies along the coast south of Kolaba. The country is rocky and fertile only on the banks of streams which are numerous.

(6) *The Tarai :*—A swampy unhealthy jungle along the base of the Himalayas. It is now being cleared and cultivated in some places.

(7) *The Sambar Lake:*—A salt-producing lake, north of Ajmere. This is the largest of the salt lakes in India and is situated in Rajputana.

(8) *Gersoppa Fals:*—In the District of North Canara; to the East ward of Honawar—a magnificent fall of water about 900 feet in height.

(9) The Coromandel Coast :—The part of the East Coast of India between the Eastern ghats and the Bay of Bengal. It is low along the coast; narrow towards the north, but broadens into the plain of the Carnatic in the south.

(10) *The Cauvery Delta* :—Is the Delta formed at the mouth of the river Cauvery. This is about 70 miles in length and is one of the most fertile parts in India.

Q. 1140. Why are the northern slopes of the Himalayas less fertile than the southern? (2) State a fact which shows that the Ganges below Cawnpur is a slow flowing stream.—M. U. 1901.

Ans.—(1) The northern slopes are perpetually covered with snow which is not favourable to vegetation. The Himalayas owing to their height do not allow the moisture carrying South-West Monsoon to pass beyond them. Thus, the other side of the Himalayas does not receive the rain from the Monsoon.

(2) The speed of a river depends upon the slope it has to flow over. The Ganges below Cawnpur has to flow over a plain and this makes it a slow flowing stream.

Q. 1141. Explain the formation of mountains.

Ans.—The earth was originally in a state of vapour: gradually it cooled down into a molten mass. When this cooled down further, the crust of the earth began to be formed. The interior, however, remained a liquid cooling gradually. Thus, the in-

terior of the earth is still in a molten condition and goes on cooling gradually. "As a consequence of slow cooling, the outer crust of our planet (the earth) has been, under the enormous strain of contraction, forced up into ridges in different places." The interior of the earth is slowly cooling. It is gradually contracting. The outer crust has to adjust itself to the cooling part of the earth's interior which is being solidified, *i. e.*, the crust of the earth has to adjust itself over a smaller space, for the interior is contracting in becoming solid. Hence, the outer crust falls into folds, as it were. These folds are hills, mountains, &c.

Q. 1142. Answer carefully the following questions:—(1) Why is there always a good supply of water in the Ganges in the hot weather? (2) How have the banks of Newfoundland been formed? (3) In Egypt rain hardly ever falls: Why is it then a great producer of cotton and cereals? (4) Why are the rivers of Siberia commercially unimportant?—M. U. 1900.

Ans. (1) The Ganges has its water-supply from the feeders coming down the Himalayas. The ice on the mountains melts in summer and the mountains send down greater quantities of water in the summer. Thus the Ganges has always a good supply of water in the hot-weather. It is in the hot-weather that the Ganges has floods.

(2) A cold current flows from the North Pole along the east coast of North America. This carries with it numerous icebergs. These icebergs carry with them mud and stones. They come into contact with the warm waters of the Gulf Stream. The icebergs melt away and deposit their mud and stones. This process taking place for ages, a great accumulation of mud and stones has been the result. Thus, the banks of Newfoundland have been formed.

(3) The fertility of Egypt does not depend upon the rain that falls, for hardly any rain falls in Egypt. The Nile carries with it the soil which is conducive to the growth of cotton and cereals.

(4) They are in frozen condition for a great part of the year. Siberia has its rivers in the Frigid Zone. Being icebound they are unfit for ships to pass. Hence, they are commercially unimportant.

Q. 1143. What and where is the great Barrier Reef?—M. U. 1901.

Ans.—*A reef* is a rocky surface, a little beneath *the sea*. The water above it is not, therefore, navigable. *Barrier Reef* is a reef formed by

the growth of coral. This encircles certain islands partly or completely.

The island is, however, separated from the reef by a navigable channel, which is sometimes many miles wide. The Great Barrier reef is 1,200 miles long and is at a distance of about 30 miles from the shore on the north-eastern coast of Australia. It is entirely coral in its origin.

Q. 1144. The watershed of Europe runs from north-east to south-west from the Ural to the Pyrenees. Explain and illustrate this statement fully.—M. U. 1901 R.

Ans.—Watershed (or, *water-parting*) is the name given to the ridge of land which separates "the water flowing into two different river-basins. This is frequently (not always) the highest line of a range of hills or mountains. Now, the greater part of Europe slopes West. On the North-West slope are the following rivers: the Petchora, the Dwina, the Duna, the Vistula, the Oder, the Elbe, the Weser and the Rhine. On the South-East slope are the following rivers.—The Elbe, the Rhone, the Po, the Danube, the Dniester, the Dnieper, the Po, the Volga.

These two sets of rivers flow, as it were, on the opposite sides of land which runs from the north east to the south-east, *i.e.*, from the Ural to the Pyreness. This part has hills, tablelands and mountains, and as it separates the two sets of rivers on the opposite sides of it, we may say that the watershed of Europe runs from the north-east to south-west.

Q. 1145. At some places the level of the land is being *slowly* raised and at other places it is slowly sinking. Explain this and give proofs in support of this statement.

Ans.—The disturbances caused by earthquakes bring about a sudden and violent movement of the earth's crust. But in addition to this, the earth's crust has been undergoing slow elevation in some parts and slow sinking in other parts: e.g. (1) There is a slow rise of the shores about the middle of Sweden; (2) On the coast of Norfolk forests are found submerged. It has been observed that when any part of the earth is being upraised, another part at no great distance is undergoing depression: e. g. the north of Scandinavia is rising but the south of it is being depressed.

Q. 1146. Explain the dissolving action of rain water and the origin of springs.—B. U. 1896.

Ans.—Water charged with carbon dioxide has the power of dissolving calcium carbonate (chalk, limestone, &c.), Ordinary water without carbon dioxide does not possess this power. The rain water in its passage through the air takes up the carbon dioxide present in it. When sinking into the earth, it becomes charged with more of the same gas (from the decaying roots, &c., that are under ground). This water will gradually dissolve rocks formed of calcium carbonate. Many caves and underground passages are due to this action of the water charged with this gas. A part of the rain that falls on the ground sinks into it and possesses in some cases a well-defined underground course. When it is forced up by the pressure of the water coming down from above, it will be forced to come out at some part of the earth near a hillside if there be a layer in the path of the water. Then it is known as spring. By digging a pit sufficiently deep, a well may be formed from which water may be pumped out or lifted up by a vessel.

These springs may be nearer the earth's surface or farther from it. In the former case the spring is called *a surface spring* and in the latter case a *a deep-seated spring*.

Q. 1147. Each of the considerable rivers on the east coast of India has a delta, *i. e.*, each river falls into the sea by several comparatively narrow mouths; but each of the considerable rivers on the east coast of Britain falls into the sea by one mouth only and that a comparatively wide one. Account for these different phenonena.—M. U. 1884.

Ans.—India. The rivers carry with them a large quantity of mud and sand. These owing to the opposing action of their currents and that of the tide at their mouth, form deltas and fall into the sea by several mouths. Secondly, the mountains in the coast also have a similar effect. They make the rivers that meet them divide into branches and fall into the sea by several mouths.

Britain :—The mountains that are the source of the rivers are in the middle. The rivers, moreover, flow along a level country. Thus, the current is not very strong. There is no tendency to form deltas. Hence, they fall into the sea by only one and a comparatively wide mouth.

Q. 1148. Why is sea-water salt. Explain the phenomena of glaciers, avalanches, and icebergs.—B. U. 1896.

Ans. (1) The numerous salts present in solution in the sea water, which "amount on the average to 3½ grains in 100 grains of water", render the sea water salt. The most abundant of these salts is the salt that we use to flavour our food. This forms 2·7 per cent.

(2) The sea has been salt from the time when it began to exist as such. When the earth has assumed its present state from its previous state, the watery part has had so many salts in solution that it may safely be said that the sea has been salt even from the beginning of its existence.

(3) Year after year, the rivers that flow into the ocean carry with them many impurities derived from the soil through which they flow. Thus, the impurities of the sea go on increasing year after year.

(4) Evaporation constantly removes fresh water from the sea. Thus, the ocean loses fresh water. For these reasons, the sea water is salt.

Glaciers :—These are rivers of ice and often several hundred feet deep. They "move slowly onward, somewhat like a viscous mass breaking at times and splitting from its brittle nature where its bed is steep or on turning a corner" These glaciers are formed thus :— In the cup-shaped upper end of those mountain valleys *above the snow line* the snow accumulates. As the snow cannot "flow off like rain it lies where it falls or is drifted by the wind and accumulates in vast masses in the hollows of the mountain flanks. In this state it is called *neve* by Swiss mountaineers. Heated by the sun during the day the surface sometimes melts, but the water formed sinking into the mass beneath becomes solidified again. "So that, in the course of time, the lower parts, pressed upon by the weight of later snow-falls above and united by the freezing water, become compacted into ice. Lying, as it does, on the steep slopes of the mountains, the *neve* gravitates gradually downwards, and, collecting in the loftier parts of the valleys, eventually forms a river of solid ice termed a glacier".

Icebergs or *ice mountains*. The Glaciers spoken of above descend a considerable distance below the snow-line. In the Himalayas they reach 9000 ft above the sea-level. In Greenland and Antarctica, however, they flow down to the sea and are "pushed out into

a depth of water, such that the whole mass eventually breaks up and floats away . . . The gigantic masses of ice which detach themselves from the glaciers are termed *icebergs*".

Fig. 137.

Avalanches :—"The accumulation of snows on the precipitous slopes of high mountains is sometimes hurled down into the valley below and is then called an *avalanche*. The earth heated by the sun, melts the under layers and destroys the adhesion of the mass to its surface. In Switzerland, avalanches are common and sometimes destroy entire villages."

Section III. The Sea.

Q. 1149. On account of the salts which the different rivers bring into the sea every year, the sea must increase in salts gradually. But it does not. How is this explained?

Ans.—The animals and plants living in the sea take up the salts present in the sea-water, e. g., shellfish, coral, foraminifera build up their hard parts from the calcium salts in the sea water. Again, some minute plants called diatoms and tiny animals called radiolaria use up silica. When these little living things die they fall

down to the bottom of the sea and form marine deposits. Thus, the salts are removed from the sea.

Q. 1150. Classify the different movements that may be observed in the sea. How do you account for those movements?

Ans:—The different movements of the sea may be classified under *tides*, *currents* and *waves*. *Tides* are caused by the attraction of the sun and the moon. The sea unlike the earth, being liquid yields to the attraction which manifests itself in the form of the tides. *Currents* owe their origin to the varying temperature of the sea-water at different parts of it and sometimes, to the winds blowing over its surface *constantly* in the same direction. *Waves* are caused by the winds that blow over it and are purely surface movements.

Q. 1151. How are the tides caused? When are they highest, and when lowest?—M. U. 1903.

Fig. 138.

Ans.—"The tides consist of the alternate rise and fall of the waters of the ocean twice in the course of an interval of nearly twenty-five hours." The cause of the tides anywhere is one and the same but for various reasons, a distinction has to be made between *Oceanic tides* and *tides in narrow passages*.

Fig. 139.

Cause of the Tides:—The tides are due to the attraction of the moon and the sun on the earth and the waters on it which are moveable. During the revolution of the moon round the earth, sometimes the moon and the sun happen to

be on the same side of the earth as in Fig 138 and sometimes on the opposite sides as in Fig 139. The former is at the new moon and the latter, at the full moon. At new moon the sun and the moon act conjointly and the sun's influence reinforces that of the moon on the earth ; and at the full moon the sun and the moon act in the opposite direction. The result in both cases is to draw away a great mass of the water from the earth. Hence, the tides are the highest in these two cases and are known as the *spring tides*. In the intermediate stages at half stages, during the first and the last quarter, the sun and the moon assume positions at right angle with regard to the earth, as in Fig 140. Now, the attraction of the sun and that of the moon counteract each other. The tides produced at these times are, thus, the lowest and are called *neap tides*.

Fig. 140.

Tides in narrow passages differ from the oceanic tides, because while the oceanic waves pass "imperceptibly at the rate of several hundred miles an hour each point of the ocean" they cannot do the same when a continental shallow part is reached. The rate of wave is checked each new coming crest tends to catch the other up. The height of the wave is increased. Thus, on the coast there is a great rise and fall of tides.

Q. 1152. Account for the origin and the direction of the currents in the ocean.

Ans. Causes of the currents : (1) The action of the great atmospheric currents known as the Trade winds which blow constantly : (2) The differences of temperature possessed by the different parts of the ocean—Equatorial parts being always hotter than the other parts : (3) Different degrees of specific gravity in different parts of the ocean.

Direction :—The rotation of the earth has an important effect upon the direction of the currents.

Q. 1153 Define ocean currents ; and classify them all in two different ways.

Ans. Ocean currents are masses of water flowing like streams in well defined directions from one part of the ocean to another. These may be distinguished by their different temperature and sometimes, by their colour.

According to *their temperature* they may be classified as *cold currents* and *warm currents*. According to their locality they may be classified as (1) currents in the Pacific ocean : (2) currents in the Atlantic ocean ; and (3) currents in the Indian ocean.

Q. 1154. Describe the currents in the Pacific ocean.

Ans.—(1) A cold current passes from the Antarctic ocean in a north-eastern direction and forms the Peru Current. This is also know as the Chili current. Later on it becomes warmer owing to the heat of the tropical regions and (abont 29°S latitude) turning west-westward merges in the great Equatorial current.

(2) The Great Equatorial Pacific current:- This is a warm current It is formed of a north equatorial current and a south equatorial current. It is as wide as the Torrid Zone itself. Driven by the Trade winds, it passes westwards up to the East Indies. Here it is broken up into several branches. One passes into the Indian Ocean. Another passes southwards to the Eastern part of Australia and New Zealand. The *main* branch, however, turns northward, passes the Philippines and then flows North East and is then called the Japanese current.

(3) *The Japanese Current.* This is also called the *Kuro sivo*. Japanese word meaning *black water*. Passing along the eastern shores of Asia it divides itself into several branches *after flowing past Japan*. Thus, Japan enjoys the benefit of its warm waters just as England enjoys the benefit of the Gulf stream passing by it though not to so great an extent. One of the branches of the Kuro,sivo reaches British Columbia and enables it to maintain a higher temperature in winter than what its situation entitles it to possess.

Q. 1155. How is the Gulf Stream generated? Describe its course and effect upon the climate of England.—Pun. Ent. Ex.

Ans:—Origin of the Gulf Stream :— An equatorial current passes from the coast of Africa to the south American coast. Near Cape St. Roque in Brazil it divides itself into two branches. One branch passes southwards and is know as the Brazilian current. The other branch passes northwards and uniting with the northern part of the great Equatorial Atlantic Current passes North West. Passing over the Caribbean sea, it enters into the Gulf of Mexico. The current makes a circuit in the gulf and comes out through the straits between Florida and Cuba. Henceforward, it is known as the Gulf Stream.

The course of the Gulf Stream :—The Gulf Stream flows along the coast of North America till it reaches Newfoundland. Here it changes its direction and passes north-east crossing the Atlantic. About the middle of the Atlantic it undergoes a division. One portion passes on under the name of the Gulf Stream drift to the shores of the British isles and Northwest Europe. The other branch pssses Southwards along Portugal and north-west Africa and at last joins the northern part of the great Equatorial Atlantic current.

Description of the Gulf Stream :—It is a warm current and its waters have a higher temperature than those of the surrounding ocean and also a distinct deep blue colour owing to the great amount of salt in solution. The temperature and dimensions are not the same throughout. At the mouth of the gulf of Mexico, it is a strong current 30 miles wide, 440 fathoms deep, possesses a temperature of over 80° F., and has a velocity of 4 miles per hour". Off Newfoundland it is 320 miles wide, about 200 fathoms deep, has a temperature of about 60° F. and possesses a velocity of a mile and a half. Near the middle of the Atlantic, where the division takes place it is only eight degrees above the surrounding water.

Effect upon the climate of England :—It renders the climate of Western Europe milder than that of the opposite coast of America. The mild climate of England is due to the warm water of the Gulf Stream.

Q. 1156. Describe the currents in the Atlantic ocean.

(1) The Great Equatorial Atlantic current. This is a warm current. It passes on both the sides of the equator from the east to the west ; we may, therefore, speak of the north equatorial current and the south equatorial current. The latter is divided into two branches at Cape St. Roque in Brazil. One branch passes southwards, as—

(2) **The Brazilian current. This is a warm current.**

(3) The other branch passes northwards and ultimately come out through the Gulf of Mexico as the Gulf Stream. Thi is a warm current. Read Q. 1155.

Q. 1157. What is the difference between the stream currents and the drift currents. Give an account of the Saragossa sea.

Ans.—Drift currents are those currents in the sea which are caused entirely by the winds blowing always in one direction, *e. g.* Gulf Stream Drift which washes the shores of North-Western Europe.

Stream currents are supposed to have their origin in a difference of temperature, (and consequently in a difference of density,) of the different parts of the sea.

The Saragossa Sea.—The Gulf Stream undergoes a division in the middle of the Atlantic ocean (at about 47° N. Lat). One branch is carried, by the winds there, as the Gulf Stream Drift to the British Isles and North-West Europe. The other turns south and joins the northern part of the Great Equatorial Atlantic current. Within the circular calm waters, a kind of seaweed (Saragossum) grows plentifully and this part is called the Saragossa sea.

Q. 1158. (1) Why does little or no rain fall on the Pacific coast of South America? (2) Why is the Mediterranean sea salter than the Black sea.—M. U. 1900.

Ans.—(1) The Trade Winds in the Southern Hemisphere blow from south-east to north-west. These carry vapour of water. They blow over South America and this watery vapour causes rainfall over the country and any more vapour that may remain in the winds is not allowed to pass over to the Pacific coast of South America, for the Andes prevent it. Thus arrested, the winds give the remaining vapour to the eastern slopes of the Andes. Consequently, the Pacific coast of South America is rainless.

The Mediterranean Sea:—It contains about one million square miles and is the largest inland sea in the world. As more water evaporates from its surface than the rivers bring in, the Mediterranean is salter than the ocean and much more so than the Black s

The Black sea:—(i) It receives one-third of the drainage of Europe. (ii) The evaporation from its surface is not proportionately great. For these two reasons, its water is not so salt as that of the ocean.

Section IV. Atmosphere, Winds, &c.

Q. 1159. (*a*) Of what ingredients is the air composed? (*b*) How are winds formed? Explain the nature of the Trade Winds.—Pun. Ent. 1900.

Ans:—

(*a*) The air is composed of oxygen and nitrogen chiefly; it contains also carbon dioxide, vapour of water, particles of dust, &c.

(*b*) Winds are caused by the unequal temperatures of adjacent parts. When two adjoining parts, for example, the land and the sea, happen to be at different temperatures, a cold wind blows from the colder to the hotter regions in the lower parts of the atmosphere; in the higher parts of the atmosphere, another wind blows in the opposite direction. The air which is next to the hotter region is heated more; it expands and becoming lighter, bulk for bulk, ascends. To take the place of this, the air next to the colder part rushes in and a wind is thus caused.

Trade Winds: These are winds that blow constantly in the equatorial regions. "They extend from a latitude of about 30° north or south to within a few degrees of the equator." The equatorial regions being the hottest parts of the earth's surface, there is a constant ascent of the heated air from those regions and to take the place of the air that has gone up, the air from the colder parts of the earth's surface rushes in towards the equator, both from the Northern and Southern Hemispheres. This is the cause of the Trade Winds. On account of the rotation of the earth on its axis from west to east they are deflected. In the Northern Hemisphere, they blow from north-east to south-west and in the Southern Hemisphere, from south-east to north-west. They are so called on account of the definite course they always maintain.

"In the middle of the Atlantic, and in the Pacific and South Indian Oceans, that is to say, in tropical seas far distant from any great mass of land, the winds blow the same way all the year round." "Sometimes great expanses of hot and comparatively dry land will suffice completely to change for a part of every year the direction of the primary currents." The monsoons of India and Australia illustrate this truth. Read the answers to Qns. 449, 1161.

Q. 1160. (*a*) What is the cause of winds? (*b*) Explain clearly the meaning of cyclone, hurricane, monsoon and typhoon, and name the regions in which they prevail most extensively.—M. U. 1893.

(*a*) Read the answer to Q. 1159.

(*b*) Word.	Meaning.	Regions in which they occur.
Cyclone ..	Literally, a circle: These are circular storms of great violence.	The Bay of Bengal.
Typhoon ..	Lit., a violent whirlwind.	In the China Seas.
Monsoon ..	Lit., seasons ..	India; Australia.
Hurricane ..	Lit., a violent storm characterised by the extreme fury of the wind.	The West Indies.

Q. 1161. Describe and explain the phenomenon o Monsoons in *India* and *Australia*.—Pun. Ent. 1903.

Ans:—"*Monsoons* are periodical winds that blow over the India Ocean and adjacent lands. In the equatorial regions, we ough to have the Trade Winds blowing constantly. But "grea expanses of hot and comparatively dry land will suffice completel to change for a part of every year the direction of the great primar air currents". The monsoons illustrate this fact.

India.—The South-west Monsoon blows from May to October and the North-East Monsoon from October to May.

Cause:—During the summer "the heat upon the southern part Asia is greater, and the air less dense than that of the Indian Ocean consequently air passes from the region of higher pressure over t ocean to the region of the lower pressure in Asia." A wind is there caused and on account of the rotation of the earth from west to eas blows from south-west to north east, from May to October and

known as the south-west monsoon. Again, during the months that are cooler to us (those in the Northern Hemisphere) the parts to the south of the Equator are hotter and the air flows from us towards the southern parts of the equator. Owing to the rotation of the earth this blows from north-east to the south-west. To us, the people of India, this is the north-east monsoon and blows from October to May. We may, in fact, consider this to be the north-east Trade Wind. *Effects of the Monsoons on India* :—"As the wind that blows from May to October (*i.e.* the south-west monsoon) travels over many hundreds of miles of the ocean before it reaches the West coast of India, it arrives heavily laden with vapour. This part of the year is, therefore, the rainy season in India. The wind that blows from October to May (north-east monsoon) does not carry any moisture with it as it has to pass over land. This part of the year has, therefore, a dry wind. Thus India has during the South-West Monsoon the rainy season, while during the North-East Monsoon a dry season.

Australia :—This country also is subject to the monsoons. But, on account of its position to the south of the equator, there is a difference between the directions of the monsoons of India and of Australia. There is a difference also in the effect. South-West Monsoon to India is rainy and North-East Monsoon to India is a dry wind. But "North-West Monsoon of Australia is wet and that from the south-east is dry." The sea which supplies moisture to the summer monsoon of India lies to the south and south-west. But it lies to north and north-west of Australia. Hence, in the southern summer months (which are cooler months to those in the Northern Hemisphere) "the heated interior of Australia leads to an inrush of cooler and moister air from the ocean." Thus, while our south-west monsoon is rainy south-east monsoon of Australia is dry and while our north-east monsoon is a dry wind the north-west monsoon is wet in north-west Australia.

Q. 1162. Account for the following :—(1) that in Madras the wind generally blows from the N. E. from October to April, and from the S. W. during the rest of the year; (2) that the climate of Madeira is so equable; (3) that the tops of the high mountains are often so cold; (4) that Malabar experiences such a heavy rainfall; (5) that the district of Tanjore is so fertile. —M. U. 1885.

Ans.—(1) Read the Q. 1161.

(2) (*a*) *Its situation* : Being in the Temperate Zone, it has the general climate of that zone, which is mild.

(*b*) Its position (being insular) also makes its climate equable.

(3) The higher we go, the colder it is. On the average an ascent of 350 feet will bring a fall of 1°C. in the thermometer. The tops of mountains do not receive the heat reflected from the surface of the earth. Hence, they are colder than the plains.

(4) The south-west monsoon laden with the vapour of water which it has taken up from the ocean, over hundreds of miles of which it has passed, is intercepted by the Western Ghauts and, hence, the moisture in it is condensed and falls down as rain. This is the reason why Malabar experiences a heavy rainfall.

(5) The district of Tanjore occupies the delta of the Cauvery. The alluvial soil which the river carries in its course and deposits at its mouth makes the district the most fertile and richest district in South India.

Q. 1163. Say exactly what is meant by Monsoon. Show that similar climatic causes produce similar climatic effects in South India and South Africa.—M. U. 1889.

Ans.—Read the answer to Q. 1160.

Similar causes.	Similar climatic effects.
(1) Both countries, South Africa and South India, are about equidistant from the equator.	Both are not extremely hot.
(2) Both possess table-lands, mountains and rivers.	These have an important effect on the climates of the two countries.
(3) South India has its own monsoons—south-west and north-east. South Africa has its trade wind.	The climate is influenced by the blowing winds.

Q. 1164. Explain the following:—Blizzard, Canon, Moraines, Pampero. Sirocco, Simoom, Typhoon and Solano.

Ans.—Typhoon: From July to October, the China seas are subject to violent and prolonged cyclonic storms called typhoons.

Simoom: This is a dry wind which blows over Arabia and Egypt from the desert. It is intensely hot and is poisonous.

Sirocco: This is also a dry wind and blows over the coasts of Malta, Sicily, &c., from the African highlands.

Pampero: A wind blowing over the pampas. This is cold and blows in a south-westerly direction.

Moraines: The pile of rock blocks carried down by a glacier and deposited at its lower end. Those at the side are termed lateral moraines; that at the end, the terminal moraine. (M. Fig. 137.)

Canon: Deep gorges with steep sides formed by rivers are known as canons in the United States.

Blizzard: Sometimes in the North East of North America a hurricane of cold wind occurs causing an extensive snowfall. It is called blizzard.

Section V. Climate, People, &c.

Q. 1165. Explain what is meant by climate and temperature. What are the causes of the difference of temperature on different portions of the earth's surface? What are the tropical regions and why are they so called?

—All. U. 1902.

Ans.—The average condition of the atmosphere as regards its temperature, pressure, moisture, &c. in any place is known as the climate of that place.

The heat of the sun does not affect the different parts of the earth's surface in the same way. Some parts are heated more and others, less. In some parts the heat of the sun is very feebly felt. In those parts where the rays of the sun fall perpendicularly or very nearly so, the heat is the greatest. This is the reason why the tropical region or the Torrid Zone is the hottest part of the earth's surface. Frigid Zones which do not have the sun for six months in the year are the coldest parts of the earth's surface and regions of perpetual ice.

Some parts of the earth's surface may be not so hot as others on account of their elevation, The temperature falls as we go higher and higher. This is the reason why the tops of some mountains are always clad with snow. Some parts do not feel extremes of temperature on account of their position. Thus, the sea coast places are not subjected to extremes of temperature as inland and hilly places are

Tropical regions are the parts included in the Torrid Zone. These are between Tropic of Cancer to the north of the Equator and the Tropic of Capricorn to the south of the Equator. They are so called because the sun seems to pass over these parts and *turn* back, so that every place within the tropical regions will have the sun overhead twice in the course of the year. Places outside the tropics will never have the sun *overhead.*

Q. 1166. (*a*) Why is the morning and the evening less warm than noon ? (*b*) Why are cloudy nights usually warmer than clear ones ? (*c*) Why is summer warmer than winter ? (*d*) Why are mountains colder than plains ?—Pun. Ent. 1900

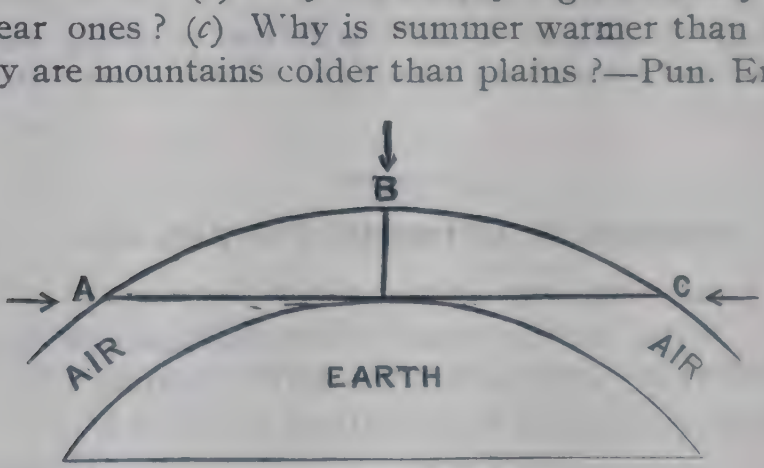

Fig. 141.

Ans.—(*a*) The heating effect of the sun's rays is the greatest when they fall perpendicularly on the surface of the earth ; the more slantingly they fall on the surface of the earth, the less will be their heating effect. The rays of the sun reach us in the most slanting manner in the morning and the evening and in the least slanting manner in the noon. Moreover, the rays have to pass through a greater part of the atmosphere of the earth in the morning and the evening and through the least part in the noon. Thus, the heat of the sun is absorbed more by the air in the morning and in the evening than in the noon. For these two reasons the morning and the evening are less warm than the noon.

(*b*) Clouds are formed by the condensation of the vapour of water in the air. When the vapour of water is condensed, the latent heat of vapourisation is given out. Hence, cloudy nights are usually warmer than clear ones.

(*c*) In the summer that part of the earth which has summer is turned towards the sun. Thus the rays of the sun fall not so slantingly as they do at other times, *i.e.*, as they do when that part of the earth is away from the sun. When that part of the earth is away from the sun it has winter. This is the reason why the summer is hotter than winter.

(*d*) Read Q. 1168.

Q. 1167. What is meant by climate? State how the climate of a country is modified by (*a*) its latitude, (*b*) its elevation, (*c*) its distance, from the ocean.—B. U. 1896.

Ans :—Read Q. 1165.

(*a*) The farther the country is from the equator the colder it happens to be.

(*b*) As the latitude increases the temperature of the place decreases. The higher we ascend the lower the temperature will be. Thus, the greater the elevation of a place the cooler it will be.

(*c*) The farther the country happens to be from the sea, the greater will be the extremes of temperature. The sea is a great moderator. The summer in a sea-coast place will not be so severe as the summer in another place of the same latitude.

Q. 1168. State and describe the various conditions that affect the climate of a country.

Ans.

Latitude :—If a place is nearer the poles it will be colder; if it is nearer the equator, it will be hotter. This is the reason why England is much colder than Africa.

Nearness of the sea :—If the sea or any other great body of water is near the place, it tends to lessen the severity of summer by making it cooler, and of winter, by making it warmer.

Madras is not so hot in summer as Hyderabad. The summer heat is relieved by the cool sea-breeze. The severity of winter is modified by the heat which the water gives out.

Elevation :—The altitude of a place has an important bearing upon the climate of a place. The higher we go, the colder the atmosphere happens to be—an ascent of 350 ft. bringing about a fall of 1° C in the temperature of the place. This is the reason why Ootacamund and Bangalore are cooler than Madras. The former is about 17,000 ft. above the sea and has a cooler climate than Bangalore which is 3000 ft. above the sea.

The Mountain chains of the country :—The mountains in a country have an important influence upon the climate of that country. If the mountain chains happen to be at right angles to the prevailing winds, they arrest the motion of the winds, and thus the moisture-carrying winds may have to deposit the moisture in the form of rain: *e. g.* The Western Ghauts, though not exactly perpendicular to the South-West Monsoon, are the cause of perpetual rainfall on the Malabar coast. Sometimes mountains afford shelter from cold winds. The plains of North Italy are protected from the cold northerly winds by the Alps.

Currents of winds :—The climate of a country depends upon the kind of winds that blow through the year, *e. g.*, North-East Monsoon in India produces important changes in its climate.

Currents of the sea :—Sometimes the ocean currents passing by a country raise or lower its temperature according as it happens to be a warm current or cold one, *e. g.*, The Gulf Stream, a warm ocean current is the cause of the mild climate which the North-west Europe enjoys. The **cold** arctic current flowing from the north past the coast of Labrador makes that much colder than Columbia on the same latitude.

The Nature of the soil—affects the climate on account of the different heat-absorbing and heat-radiating powers of various rocks. A sandy waste like the Sahara absorbs a great quantity of heat during the day and radiates rapidly during the night, while wet and marshy grounds lower the mean temperature by conducting the heat downwards.

Q. 1169. What is the *snow line*? Is it the same in all places? State the conditions that affect it.

Ans.—The snowline is the height at which the temperature is below the freezing point and is the limit above which, so much snow falls that the summer heat is not able to melt it. It is the height at which snow remains unmelted throughout the year". It is not the same in all places.

Near the Poles it is at the sea-level ; in Iceland at 3,070 feet ; on the Alps at 8880 ft, ; on the Andes at 14,760 and so on.

It depends upon (1) the latitude of a place, i.e., the distance from the Equator. The farther a place is from the Equator the nearer will be the snowline to the earth. (2) It depends on the prevailing winds. (3) It depends also on the amount of snowfall in a given time.

Q. 1170. Upon what circumstances does the temperature of a place chiefly depend. Account for the following facts :—(1) Although Edinburgh is in the same latitude as Moscow, the intense cold of the winter of the latter place and the heat of its summer can be ill-endured by a native of the former. (2) The summer of Lapland is very hot.—M. U. 1883.

Ans:—Read Q. 1168.

(1) In winter Moscow is colder than Edinburgh for the following reasons :—It is situated in an elevated plain and there are no mountains in the north to prevent the Arctic blasts. In summer, Moscow is hotter than Edinburgh for the following reasons. Moscow being situated in the interior and not on the sea coast there is no sea to mitigate its summer heat. Being situated in a plain the winds that blow do not pass over water and reach the place in a cool state as they do in Edinburgh.

(2) Lapland is within the Arctic circle. During summer it has a perpetual day for 6 months as the North Pole of the earth will be turned towards the sun during the summer. Hence, the summer in Lapland is hot.

Q. 1171. Acconnt for (1) the mild moist climate of Ireland, and (2) the excessive rainfall on the Malabar coast. —M. U. 1888.

(1) *The climate is mild* :—This is due (1) to the Gulf Stream, which flows from the Gulf of Mexico and warms the West coast of Ireland ; (2) is an island and this has an important bearing upon its climate.

The climate is moist : This is due to the west wind from th ocean. Passing over hundreds of miles this wind carries moistur with it and first breaks upon Ireland.

(2) Read Q. 1162.

Q. 1172. How do the '*Oceanic*', '*insular*' and con tinental climates differ from one another ? Give examples.

Ans :—*Oceanic climate* is that possessed by a place surrounde by the sea. It is entirely regulated by the sea. Small island show the oceanic climate particularly well, *e. g.* Island groups i the Pacific ocean, though in the Torrid Zone, enjoy a most equabl temperature.

Insular climate is also known as the coast climate. This is th climate enjoyed by the sea coast places and the heat of the day is re lieved by the presence of the sea. The severity of winter also i mitigated by the sea.

Continental climate. This is also known as *land climate.* I this climate the extremes of te nperature are great. The summe is very hot and the winter is very cold. *E. G.* The mean summe and winter temperatures of Edinburgh are 57°F. and 3°F respec tively. Of Moscow 64° and 15°F.

Q. 1173. (1) Explain precisely why Madras is hotte than Aberdeen. (2) Account for the difference between th climates of the Arabian and the Indian Peninsulas—M. U 1901.

Ans :—Both of them are in different Zones. Aberdeen is in th temperate zone.

(2) Arabia.	India.
1. It is subject to a scorching wind called the simoom.	1. Receives its supply of ra from the South-West Mo soon.
2. Much of the north and south consists of sandy des ts.	2. There are many mountai and rivers.
3. No navigable rivers in the whole country.	3. It has only a small dese somewhere in the north-we
4. It forms a part of the rainless zone of Asia.	

Q. 1174. Answer shortly but carefully the following questions :—(*a*) Why is the climate of Edinburgh more temperate than that of Moscow ? Why is it cooler in Madras during May than it is at Lahore ?—M. U. 1903.

Ans :—(*a*) Read the answer to Q. 1170.

(*b*) Madras is a sea-coast place. Lahore is situated in a plain and is thus an inland town. The heat of the summer is relieved by the sea breeze in Madras, while that is not the case in Lahore.

Q. 1175. Contrast the general character of the food and clothing of mankind in the several zones of the world.

M. U. 1882.

Ans.

Zone.	Food.	Clothing.	Cause.
The Torrid Zone.	Rice, maize, plantains, cocoanuts, &c.	Cotton clothing	Being the hottest parts, these things grow there : people do not require warm clothing.
The Temperate Zone.	Wheat, barley, oats, vines, oranges, &c.	Woollen, cotton and linen clothing.	The climate is mild.
The N. Frigid Zone.	Flesh of the seal, reindeer, fish.	Fur of animals.	Vegetables, plants and fruit trees do not grow there, owing to the very cold climate. They use fur to protect themselves against cold.

Q. 1176. "The nearer we go to the Equator the more numerous and vigorous are the varieties of plant life". Account for this.

Ans :—Plants require for their proper growth sufficiently hig temperature and enough of rainfall. Where there is 'high temper ature and abundant rainfall" vegetation is most luxuriant; but i proportion as either of these conditions is wanting the vegetatio becomes scanty and stunted'. The tropical regions possess a hig temperature and have abundant rainfall. Hence, the plant life her is vigorous and varieties numerous.

Q. 1177. What are 'deserts'? How have they bee caused? What are oases?

Ans. Those tracts where vegetable life is not to be found at a are called deserts.

Absence of heat and *absence of water* are the two causes that giv rise to deserts: *e. g.* deserts in the polar regions are due to th absence of heat; deserts in the tropical regions, as the Sahara, ar due to the absence of water.

Oases are fertile spots in deserts :as oases in the desert of Sahara

Q. 1178. What is flora? Explain why all kinds of tree do not grow in every part of the world.

Ans. The term *flora* is applied to all the plants that grow in given tract.

All plants do not require the same amount of heat an moisture. For some, the moisture in the air is enough: for others, we earth is absolutely necessary.

Different parts of the earth differ in their temperature and mois state of the air. Hence, all trees do not grow in every part of th world.

Q. 1179. What are plant zones? Name them an give five characteristic trees and plants for each zone.

Ans. Plant zones are the different parts of the earth divide according to the characteristic trees and plants produced therein.

The Equatorial Zone—Palm trees, banyan trees, sago, bamboo and gigantic creepers. &c. 15°, both sides of the Equator: Temp rature 80°F.)

The Tropical Z one—Tree ferns, figs, coffee, cotton, sugarcan &c. (15 to 23½° on both sides of the Equator: Temperatu 75° F.)

The Sub-Tropical Zone—Orange, olive, pomegranate, vines, rice, &c. (23½° to 34° on both sides of the Equator: Temperature 65°F.)

The Temperate Zone.—Walnut, oak, chestnut, wheat, eucalyptus, oats, grapes, potatoes, cabbages, &c. (34° to 58° on both sides of the Equator: Temperature 48°F.).

The Sub-Arctic Zone—Pines, firs, barley, poplar, &c. (58° to 66°: Temperature 40° F.).

The Arctic Zone—(Temperature, even to 20 degrees below the freezing point)—Mosses and lichens.

Q. 1180. A is an inhabited place in the Arctic regions, and B another in a well-watered tropical region; what will be the dress, the chief occupation and the food of the inhabitants of A and B, respectively.—M. U. 1884.

Ans.

Inhabitants of	Dress.	Occupation.	Food.
A.	Sheep and deer skins.	Hunting and fishing.	Fish and flesh.
B.	Cotton cloths.	Agriculture, manufacture, industries, &c.	Rice, maize, millet, cocoanuts, dates. &c.

Q. 1181. It is quite possible to have in one and the same country the whole of the vegetation found in all the plant zones. Explain how this may be.

Ans. This is possible only on high mountains. For, a rise in the elevation brings about a fall in the temperature. Hence, the vegetation at different heights of mountains is similar to that in the corresponding zones of vegetation. As we ascend a mountain, we pass through all the zones of vegetation mentioned above. On the Alps, for example, we may begin the ascent in the midst of vine-

yards, but at about 2,000 feet these disappear and give rise to oaks, beeches, etc.

Q. 1182. What is 'fauna'? Describe the characteristic features of the fauna of the different zones and state any exceptions and noteworthy facts.

Ans. The term 'fauna' includes all the animals *native* to any particular country. In the tropics the animal life is most abundant—the largest, the strongest, and the fiercest being found there. Animals which inhabit the ocean are an exception to this fact, for we have the strongest and largest animal in the whale which lives in the Arctic seas, and is seldom seen in the warmer parts. A noteworthy fact is that the shark, one of the strongest and fiercest fishes, is found mostly in the warmer seas.

Q. 1183. "The ordinary animals of different continents are *widely different.* Nevertheless, there are generally broad similarities which suggest that all these must have had *the same origin.*" Explain this statement with reference to the points in italics.

Ans. Asia and Europe have one hundred and sixty kinds of animals that chew the cud, such as buffalo, sheep, deer, &c.

America has only sixteen kinds and Australia has none.

Similarities :—Many species of animals of the old world correspond closely to the animals of the new world. Cf. the buffalo of the old world with the bison of the new: the camel, with the llama: the ostrich, with the rhea.

Q. 1184. What are said to be 'exotics'. Give three well chosen examples

Ans. Exotics. Plants or trees introduced from a foreign country and are not native of the soil on which they grow *e. g.*

(1) Maize, potato, and tobacco—introduced into Europe in the 16th century.

(2) Rice—indigenous to Asia—introduced into America about the middle of the eighteenth century.

(3) Cinchona—indigenous on the slopes of the Peruvian Andes—introduced into India and Ceylon.

Q. 1185. Two ships sail from London to Bombay, and from Bombay to London, respectively. State the probable cargo in each case from the following list: wheat, hardware, hides, cotton, books, glassware, indigo, oil, machinery, woollen goods, jute, coal, tobacco, leather manufactures, opium, earthenware.—M. U. 1891.

Ans.

Ships	Cargo.
From London to Bombay.	Woollen goods, machinery, leather manufactures, earthenware, books, glassware and coal.
From Bombay to London.	Wheat, hides, cotton, indigo, oil, jute, tobacco, and opium.

Q. 1186. State, with reasons, the climate most favourable to the vigour and intelligence of a nation.

Ans. If the climate be hot as in the tropical regions, clothing is hardly necessary. The fruit-bearing trees supply the necessary food without cultivation. Thus the food being supplied without exertion on his part, the ingenuity of man is not called into play and so he is undeveloped. Moreover, the excessive heat unfits him for any sustained effort.

If the climate be very cold as in the arctic regions, the severe climate leads man to secure the bare necessities and nothing more.

Thus, the temperate climate of the Temperate Zone is the only climate where man is obliged to work for food and clothing and also for storing them for winter. These are incentive to prudence, thrift, inventiveness and those qualities which raise a nation.

Q. 1187. Account fully for the fact that in North America the 'redskins' are not so numerous as they were at one time. Mention another case which illustrates your answer.

Ans. "Man dispossesses his fellow man in some districts.... Barbarous races appear incapable of adopting a civilized mode of

life, and therefore disappear before races 'superior alike in physical type and in the arts upon which progress depends.' In Tasmania the original black has become extinct and his place has been takes up by the white man".

SECTION VI. GENERAL.

Q. 1188. Name the various divisions of Geography and state the points of difference therein as regards the subjects treated by them.

Ans.

Divisions of geography.	Subjects treated.
1. Mathematical Geography.	(*a*) Shape and size of the earth. (*b*) Motions of the earth. (*c*) The relation of the earth to the sun, moon and other heavenly bodies.
2. Physical Geography.	(*a*) Natural phenomena of the earth's surface. (*b*) Movements of the air and ocean. (*c*) Distribution of life upon the earth. (*d*) The natural forces which continually modify the earth.
3. Political Geography.	The distribution of political power, the boundaries, populations and resources of states and empires.
4. Commercial Geography.	(*a*) The animal, vegetable, and mineral products of each country. (*b*) The development of the products by man. (*c*) The ways and means by which those products are sent from place to place.

Q. 1189. In nature some springs spontaneously sto for a time. Explain the phenomenon.—B. U. 1898

Ans.—Some reservoir under the surface of the earth receives rain water through a series of fissures in the earth. (F, F, Fig. 142) This reservoir (R. Fig. 142) communicates with outside by a channel. When this reservoir is filled the water continues to flow through

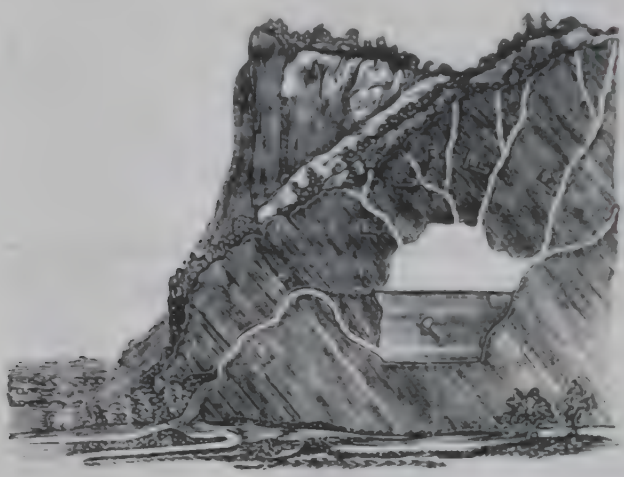

Fig. 142.

the channel and the water comes out as a spring. When the water in the reservoir falls below the level of the channel, the spring ceases to flow. When the reservoir receives water, so that it may be above the level of the channel that communicates with the outside, the spring once more makes its appearance. Springs of this kind are known as 'intermittent springs' and they act on the principle of syphon as can be understood by the figure.

Q. 1190. Explain the following :—(1) Atoll, (2) Beach, (3) Cold Wall, (4) Denudation, (5) Erosion, (6) Geysers, (7) Isobars, (8) Landslips.

Ans.—

(1) Atoll is a kind of island which is very common in the Pacific. It is a ring-shaped coral island and rests on the sides of a submerged hill. It has a central lake or lagoon.

(2) The part of the sea-shore between the low water mark and the high water mark is called the beach.

(3) *Cold Wall*.—That part of the North Atlantic Ocean near the coast of North America which is the boundary line between the Gulf Stream and the Cold Arctic current.

(4) *Denudation* is the wearing of the earth's surface by rain, wind, &c.

(5) *Erosion* is the wearing of rocks by streams, rain water, &c.

(6) Geysers are hot springs which throw out hot water continuously or at intervals.

(7) *Isobars* are the (imaginary) lines that connect places having the same barometric pressure.

(8) *Landslip* is the falling down of a mass of land or a piece of rock owing to such causes as earthquake, action of water, &c.

Q. 1191. State the various ways in which lakes are formed, and explain why some contain fresh water and others saltish. —Pun. Ent. 1903.

Ans.—Lakes are bodies of water surrounded by land on all sides. They are formed in various ways: (i) A landslip or a stream of lava obstructing a river valley may give rise to a lake. (ii) A river valley gradually subsiding may give rise to a lake. (iii) The bed of a river gradually rising is another cause for the formation of a lake. (iv) The craters of some extinct volcanoes may also give rise to lakes.

(i) Some lakes are salt on account of their connection with the sea; *e.g.*, Chilka lake.

(ii) Some lakes have been parts of the sea from which they have been cut off owing to the changes in the earth's surface. These are salt lakes, *e.g.*, the Caspian Sea.

(iii) Some lakes receive rivers: but owing to the vastness of their area and dryness of the place there is no outlet and the water is evaporated, leaving the salts brought by the rivers behind. These lakes are thus salt lakes, *e.g.*, The Dead Sea.

Fresh water lakes have an inflowing river as well as an outlet. Their water is thus replenished. These remain fresh water lakes.

Q. 1192. Define archipelago, estuary, glacier, isthmus, oasis, latitude.—Cal. Ent. 1903.

Archipelago: "Any body of water abounding with islands is called an archipelago. The islands themselves are also called by that name.

Estuary is the lower part of a river communicating with the sea and along which the tidal wave passes.

Glacier is a river of ice that is formed on the upper part of a high mountain and slowly moves on.

Oasis Read Q.?

Latitude is the angle included by two lines drawn from the centre of the earth one of which intersects the place and the other the point of the equator nearer to that place.

Q. 1193. Explain by the help of a diagram the principle of Artesian well.—Bom. U. 1897.

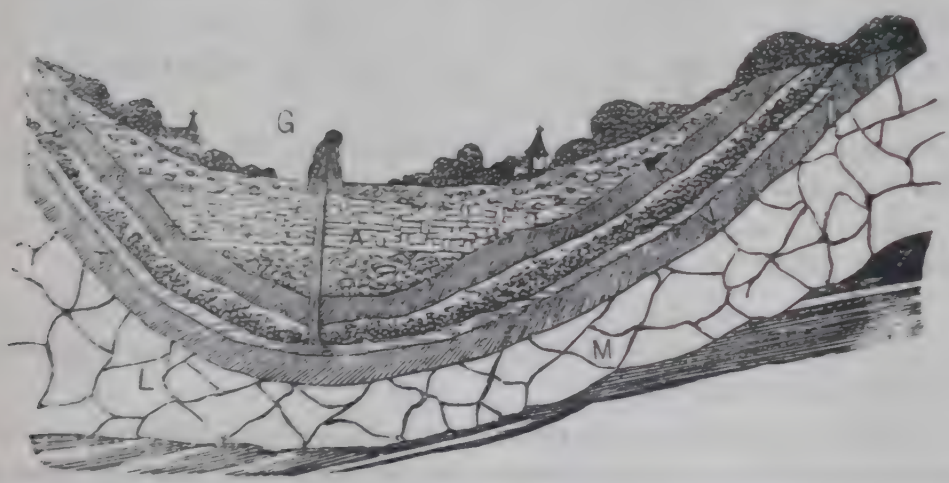

Fig 143.

Ans. Artesian wells act on the principle that liquids always try to find their level. The spring which supplies water to an artesian well comes from a place which is much higher than the place where the artesian well happens to be. The water goes on flowing under ground till at last it meets with impermeable layers (layers through which water cannot pass.) Now the water collects here and remains at a pressure. It tries to reach the level of the water at the source. Now if a shaft be sunk down to the layer of earth carrying such water, it will spout out to a height which depends upon the level of the water at the source. As can be easily imagined Artesian wells can only be found out by trial and it is not every place which is suitable for an Artesian well.

Q. 1194. Define loam, shale, weathering, dunes, exotic, phase, mirage, bore.—Pun. Ent. 1901.

Ans. Loam is the name given to the earth which is a natural mixture of clay, sand, and decayed vegetable matter. This is found sometimes in excavations.

Shale—"Stratified deposits, originally of clay or fine sand, hardened and compacted by pressure and readily splitting along the planes in which they have been deposited''.

Weathering—The decomposition and disintegration of rocks owing to the chemical action of carbon dioxide, oxygen, water vapour, and varying temperature, is known as the weathering of rocks.

Dunes are the sandhills which are formed on certain sea coasts or the margin of rivers with broad sandy beds; these run in a direction at right angles to the prevailing winds and often extend over miles.

Exotic, literally means foreign, and denotes the plants or animals of foreign origin introduced into a country.

Phase, as applied to the moon or a planet, denotes the appearance presented day after day by it.

Mirage is the false appearance of water in hot dry plains on account of the reflection of light from the surface of the heated air under certain conditions.

Bore is the name given to the "high wave formed by the advancing flood tide in certain estuaries, where the tidal wave is retarded by the shallowness of the channel and raised by the convergence of the shores". It is a tidal flood of great height and force formed at the mouth of some rivers.

Q. 1195. Show, by the illustration, from any Indian rivers, the effect that rivers have upon surface of the earth.—M. U. 1902.

Ans:—The action of the rivers on land is two-fold:—They carry sediment and, depositing that at their mouths, give rise to deltas, sandbanks, bars.

Secondly: Owing to their erosive action the surface of the earth is denuded and valleys, ravines and canons are formed, *e. g.* The Kistna and the Godavari deltas at their mouths. The Surma valley is noted for its tea plantations.

Q. 1196. What are the 'Roaring Forties'? What is their importance to sailors?

Ans: The Trade winds blow in the Northern Hemisphere in a North Easterly direction but they are not allowed to have that direction in certain parts owing to the way in which land has been distributed, the presence of mountain ranges, &c.

In the Southern Hemisphere there is not so much land as in the Northern. So, the Trade Winds are allowed to blow steadily. The direction of the Trade Winds in the Southern Hemisphere is south-easterly. The winds blow steadily and forcibly in the Southern Hemisphere, particularly between 42° and 50° Lat.

These Latitudes are called by the sailors Roaring Forties. In this belt, the winds blow steadily throughout the year and help the quick passage of the vessels going to New Zealand by the Cape of Good Hope and those that return by Cape Horn.

Q. 1197. Explain the following terms:—Fossil, bar, cyclone, hoar frost, spring tide, breaker.—Pun. Ent 1904.

Fossil in modern science means any remains of animal or vegetable body or the traces of their existences found in the rocks of the earth, *e.g.* shells, bones, foot-prints, &c.

Bar of a river is the bank of sand &c. running across the mouth of certain rivers and obstructing their entrance into the sea.

Cyclone is a violent atmospheric disturbance in which the winds blow like a corkscrew, in direction, towards the region of low barometric pressure in the centre. The central region is calm.

Hoarfrost: when dew is deposited in a solidified condition it is known as *hoarfrost* or *rime*.

Spring tide. See Qn. 1151. It is the highest tide and occurs at full moon and the new moon.

Breaker. When the waves of the sea are obstructed by the shallowness of the water, or by a rock, they break up in masses of foam, and are known as breakers.

Q. 1198. Name (1) the highest lake, (2) the largest lake, (3) the deepest lake, and (4) the lake that contains largest percentage of salt in solution.

Ans. (1) Askalchin in Tibet. (2) The Caspian Sea. (3) Lake Baikal. (4) The Dead sea.

Q. 1199. State (*a*) why the Red Sea is salter than the Baltic. (*b*) Whence fish and other animals that live in water receive air to breathe. (*c*) How sea water loses its lime sometimes.—Pun. Ent, 1904.

Ans. (*a*) The Baltic Sea is shallow and owing to the numerous rivers which fall into it, the water is not so salt as that of the ocean the Red Sea is salter than the Baltic, because many rivers do not flow into it.

(*b*) The air that is dissolved in the water supplies the necessary oxygen for the fishes and other aquatic animals.

(*c*) Countless numbers of small creatures termed Foraminifera live in the ocean, "These have the power of taking up the carbonate of lime from sea water. Read Q. 1158.

Q. 1200, What and where are the following :—

(1) The equatorial Belt of calms, (2) the Doldrums (3) Tornado, and, (4) the great Barrier Reef.

Ans. (1) This is near the equator : here the pressure is low. It is a few degrees in breadth and will be changing its position according to the change of seasons. It is characterized by frequent heavy rains and thunderstorms.

(2) Doldrums is another name for the Equatorial Belt of calms.

(3) Tornado : this is a local cyclone of great violence which is usually accompanied by a great downfall of rain.

Q. 1201. How do frost, rain, and wind help to reduce the inequalities of the earth's surface ?—M. U. 1903.

Ans. These two help each other to remove the inequalities of the surface of the earth. When rain falls the water enters into the interstices of rocks and when the frost comes it expands in becoming ice and the particles of rock are forced away from the mass. thaw setting in a contraction of the mass takes place and the loosened particles of the rock are washed away by fresh rain or fall down by their own weight. Again, the rain in the form of rivers an

streams carries away particles of mud or sand from higher ground to lower places elsewhere.

Wind acts as rivers. It carries particles of sand or earth from higher ground and deposits it in the lower. In this way cities have been buried. (Nineveh); fertile plains have been formed (the plain of Hoangho); deserts have been created (the Sahara).

Q. 1202. Explain the following paradoxical statements;—(1) The salt in the sea is in a great part due to the fresh water rivers: (2) It is the heat of the sun that produces snow.

Ans. (1) Year after year evaporation removes fresh water from the sea and the rain that falls down on the earth is fresh water and causes streams and rivers. These fresh water rivers carry along with them so many salts from the lands through which they flow. These salts all find their way into the ocean and are deposited there. The fresh water is again evaporated. Thus, it is to the fresh water streams the salt of the sea is due in a great measure.

(2) The heat of the sun causes water to evaporate. The atmosphere receives its vapour of water in this way At higher parts of the atmosphere this vapour of water is deposited as snow on the tops of mountains. Were it not for the heat of the sun the atmosphere would not carry with it the vapour of water and give rise to snow on the tops of mountains.

Q. 1203. The average duration of a sailing voyage from Liverpool to New York is 33 days; from New York to Liverpool 22 days. Explain the difference supposing the route taken both ways to be the same.—M. U. 1901.

Ans. When sailing from Liverpool to New York the ship has to go against the Gulf Stream and so its velocity is retarded and it takes a longer time to reach New York. But when it has to return from New York to Liverpool the Gulf Stream helps it, as it passes in the same direction as the ship. Thus, the ship reaches its destination sooner.

Q. 1204. "To get the local time add 4 minutes for every degree, for a place east of Greenwich and subtract 4

minutes for every degree for a place west of Greenwich". Give reasons for this.

Ans. Almost all nations reckon longitude from the meridian of Greenwich. The earth rotates on its axis once in 24 hours. Therefore the 360 degrees on the earth's surface pass under the sun in 24 hours. Thus each degree passes under the sun in 4 minutes. There will be a difference of four minutes time for every degree by which one place is separated from another. As the sun is first seen in the east the time of the places to the east of Greenwich is in advance of the time of Greenwich. As the places west of Greenwich will have the sun later on, the time in the place west of Greenwich will be behind the time of Greenwich. Hence, to get the local time we have to add 4 minutes for every degree by which the places east of Greenwich are separated from it; and we have to subtract four minutes for every degree by which a place to the west is separated from Greenwich.

Q. 1205. When it is 12 noon at Greenwich what is the time at place 90° East ?—M. U. 1902.

Ans. For every degree of longitude there is a difference of 4 minutes.

∴ ,, 90° ,, there is a difference 6 hours.

The place being east the time will be in advance : it would have its noon six hours before.

∴ It would be 6 p.m. at that place when it is 12 noon at Greenwich.

Q. 1206. A telegram despatched from Calcutta to London at 1 a. m. on the 11th September, occupied two hours in transit and reached its destination at 9 p. m. on the 10th of the same month. Account for that—M. U. 1882.

Ans. The longitude of Calcutta is 88°30 E.

,, ,, London 0° 5'' 48'' W.

London is nearly 89 degrees to the west of Calcutta.

For every degree of longitude there is a difference of 4 minutes in time.

Being west London time is behind Calcutta time by 89 × 4 minutes or 6 hours nearly.

When it is 1 a. m. at Calcutta it would be 7 p. m. at London the previons day.

The telegram takes two hours in transit.

Therfore, it reaches London at 9 p. m. on the 10th of September.

Q. 1207. If it is 7 *p. m.* at Delhi, 77°30′ East longitude, What would be the time at (1) Pekin, 116°28′ east, and (2) San Francisco 122°west ?,—Pun. Ent. 1903.

Ans. 116°28—77°30′ = 38°58′

(1) ***Pekin:—***

∴ Pekin is nearly 39° east of Delhi for each degree there will be a difference of 4 minutes in time.

∴ For 39° there will be a difference of $\frac{39\times4}{60}$ = 2hrs 36′.

As Pekin is east of Delhi, the time will be in advance. Hence, the time at Pekin will be 7+2 hrs 36′ = 9 36′ p. m. when it is 7 p. m. at Delhi.

(2) ***San Francisco:—***

This is 122° west of Greenwich. But Delhi is 77°30′ east of Greenwich. Therefore, San Francisco is 122°+77°30′ = 199°30′ west of Delhi.

For every degree there is a difference of 4 minutes in time ∴ for 199½°there is a difference of $\frac{399}{2}\times\frac{4}{60}$ = 13hrs 18.

But San Francisco is west of Delhi. Therefore, the time will be behind the time of the places to the east of it : for, the places to the west will have the sun rise later than the places in the east. Therefore,it will be 5-42′ a.m., at San Francisco, *i.e.*, when it is 7 p.m. at Delhi it will be about the day break of the same day in San Francisco.

Q. 1208. (1) What is meant by '*projection*' (2) How is this of importance to us ? (3) State the various kinds of projection and the merits and defects of each.

Ans. (1) The word *projection*' literally means *throwing forward* and is used to denote the process by which a spherical surface is represented on a flat sheet.

(2) The earth is almost spherical. It is necessary that the earth as a whole or in parts, should be represented on flat maps. Hence, it

is important to us to know something about the way in which flat maps of the spherical earth are prepared and how far these flat maps accurately represent the size and shape of the different parts of the earth's surface.

(3) i. *Orthographic projection.*—

In this, the central part of the globe alone is correctly represented. Equal parts of the globe farther from the centre appear unequal and smaller on the map prepared according to this method of projection. So this projection is not used for maps.

ii. *Stereographic projection:*—

In this, the equal distances on the surface of the globe farther from the centre appear unequal and bigger on the map prepared according to this method of projection. In this method of preparing maps, the middle of the globe comes out properly.

iii. *Globular projection* :—This is intended to modify the defects of the two preceding projections. Even in this method of projection the outer portions of the map suffer distortion. Nevertheless, this method is in common use and geographers project maps on this method.

iv. *Mercator's projection* :—This method of projection is used when the *whole of the Earth's Surface* is to be represented on a flat surface. The former methods are used when the Eastern Hemisphere or the Western Hemisphere is to be represented on a flat map. A map prepared on Mercator's projection exaggerates the places near the poles, *i.e.*, they appear to be larger than they are. Hence it is usual to stop the map at 80° of latitude. This projection is useful to show the relative directions of the different parts of the earth. (2) the ocean currents, (3) isothermal lines, &c.

v *Conical projection* : This is used in maps which represent only a section of the surface of the earth, as for example a continent. In this method there is no distortion at the edges of the map. Slight modifications of this method enable geographers to produce very accurate maps of the required parts of the earth.

Q. 1209. State the points of resemblance and of difference between rivers and glaciers.

Ans : *Resemblance* : (1) Both begin in high ground and finish lower down : (2) Both move faster in the middle than at the sides : (3) Both 'wear out' the country over which they travel : (4) Both

transport rocks large or small from one part of the country to another."

Difference : (1) 'Rivers contain water and glaciers are composed of ice : (1) Rivers move more or less quickly, whereas glaciers move very slowly: (3) Rivers are found in all parts of the world whereas glaciers are found only in the upper valleys of high mountains : (4) Rivers are of various lengths, even up to 4,000 miles while glaciers rarely exceed 12 miles : (5) Rivers are useful as means of communication, whereas glaciers are not useful as means of communication.

Questions for Exercise.

Q. 1210. Describe the four different ways in which rocks are formed and name a place where each kind is formed.—Pun. Ent. 1901.

Q. 1211. Describe a volcanic eruption suggesting possible cases.—Cal. Un. 1904.

Q. 1212. What regions of the earth are still unexplored or little known ?—All. Un. 1902.

Q. 1213 Explain each step in the formation of a delta. Give illustrative examples—Pun. Ent. 1902.

Q. 1214. "The earth is the scene of continual movement and change." Explain this fully and give as many examples of such "movement and change" as you can.—B. U. 1899

Q. 1215. Explain clearly the various bad effects of destroying the forest area. How are deserts formed ? —Pun. Ent. 1901.

Q. 1216. How will you prove that the interior of the globe is at a very high temperature.—Bom. Mat. 1903.

Q. 1217 Sometimes the mass of the earth itself is added to by the heavenly bodies. What are these heavenly bodies and how do they add to the earth's mass ? What phenomena are observed in connection with them ?

Q. 1218. What is an alluvial plain and how was it produced ? —All. Un. 1902.

Q. 1219. (*a*) Through what continents does the equator pass ? or Mention (*b*) an important town, (*c*) a large lake, and (*d*) three large islands on or near it : (*e*) what parallel is $23\frac{1}{2}°$ north of the equator, and (*f*) what parallel is $23\frac{1}{2}°$ south ?—M. Mat. 1880

Q. 1220. All places in a given longitude have noon at the same time. Explain this statement.

Q. 1221. Suppose a person is to follow the line of the equator throughout its entire length. Describe as nearly as you can the parts of the world he would pass over.—M. U. 1901. Re.

Q. 1222. What becomes of the rain when it has once fallen? Explain the formation of springs. What effect has the rainfall on the surface of the earth?—Pun. Ent. 1900.

Q. 1223. What is the difference between a bed of sand and a bed of clay as regard the passage of water through them? and how does this difference affect the nature of the soil? How do you account for the occurrence of marshy places in hilly ground? How is the underground circulation of water shown by wells, mines and pits.—Cal. Ent. 1903.

Q. 1224. State and account for the position of the principal desert regions of the globe.—Lon. Mat. 1902 Sep.

Q. 1225. When is the mouth of a river called an estuary? Mention another name by which an estuary is sometimes called. —M. U. 1883.

Q. 1226. How do you account for the desert of Gobi (north of the Himalayas)?

Q. 1227. Explain the origin of rivers (indicating the action of gravity). What is meant by a *watershed*, and what by a *delta*? Give some account of the wear and tear of rivers. How are terraces formed?—Cal. Ent. 1903.

Q. 1228. Give some connected account of the lake system of North America and of the mountain system of India.—M. U. 1887.

Q. 1229. Account for the fact that although Asia is the largest division of the globe, its rivers are not the longest in the world.

Q. 1230. What and where are the following:—Karroos, Savannahs, Cannons, Steppes, Dunes?—M. U. 1903.

Q. 1231. Give a short description of the Tell, the Maremma, the Tarai, and the Rann of Kutch.—M. U. 1888.

Q. 1232. Compare and contrast, with respect to physical features, either Asia and Europe or North America and South America. —M. U. 1890.

Q. 1233. 'The earth is a scene of constant change.' Explain this with reference to examples (1) showing that what is now lan

was formerly water, (2) what was once a town is now a desolated place, (3) what was once the bed of a river is now a plain.

Q. 1234. Describe (*a*) the colour of the ocean, (*b*) its depth, (*c*) the reasons for its saltness, (*d*) effect of its action on the land, (*e*) its effect on climate, and (*f*) the life it contains.—Pun. Ent. 1901.

Q. 1235. Describe the motions of the sea. Explain the cause and effect of waves. Illustrate the effects of water on stones and rocks.—Cal. Ent. 1903.

Q. 1236. Write short notes on (1) The Labrador current, (2) The Kuro Sivo, (3) The cold wall, and (4) Gulf Stream Drift.

Q. 1237. 'The sea is never at rest.' What are the causes that do not allow it to be so ?

Q. 1238. Volcanoes are on the sea coast or very near it. Trace the volcanic line in the Pacific ocean.

Q. 1239. State the important effects of a volcanic eruption on the sea. Explain the cause of the tides.—M. U. 1893.

Q. 1240. A cold current of the sea, coming into contact with a warm current causes dense fogs. Why is this so ? State two places where the fogs are due to this cause and the currents which give rise to those fogs.

Q. 1241. Give the position and nature of (1) the Aghulyas current, (2) Antractic current and (4) Mozambique current.

Q. 1242. State the difference between :—*Beach* and *sea-shore*, (2) *breakers* and *waves*, (3) *tides* and *bores*, (4) *streams* and *drifts*.

Q. 1243. Give a diagram to show the general surface circulation of the Atlantic ocean. State the cause of which the movement of the water is due, and the effect of the currents on the climate of the regions passed by them.—Lon. Mat. 1902. Sep.

Q. 1244 How do winds arise ? How are they affected by the quantity of water vapour in the air ? Explain the phenomena of land and sea breezes and of trade winds.—Cal. U. 1904.

Q. 1245. What are monsoons ? Describe generally the course of the monsoons in Southern India throughout the year.

—M. U. 1892,95.

Q. 1246. What is the effect of the monsoons on India ? Are there other places affected by them ? If so, what are they and how are they effeted ?

Q. 1247. Contrast the climatic conditions on the two sides of the Irish sea, and explain the differences. Point out the chief

geographic causes which have influenced the nature of the occupations pursued east and west of the sea. —Lon. Mat. 1903 Sepi

Q. 1248. Madras is nearer the Equator than Bellary while Ootacamund is nearer still but Madras is cooler, and Ootacamund is still more so, than Bellary. What may be the explanation of these facts ?

Q. 1249. On the whole the climate of Japan is 10° colder than that of corresponding latitudes of Europe. Account for this —M. U. 1901 R.

Q. 1250. The Equator passes through Africa as well as South America. Why then is Africa hotter than South America ? Give five reasons.

Q. 1251. Trace the course of one important isothermal line around the globe and account for the principal peculiarities which it presents. —Lon. Mat. Jan. 1904.

Q. 1252. North America as well as Europe are situated in the North Temperate Zone but the former is colder than the latter. Give four reasons for the fact.

Q. 1253. Account for the great rainfall on the West Coast of (1) Tasmania, and (2) New Zealand.

Q. 1254. How do ocean currents affect the climate of a country? Illustrate from a current in the Pacific Ocean.—M. U. 1902.

Q. 1255. (1) New York and Madrid are in the same latitude, but the climate of New York resembles that of London which is still farther north. (2) Labrador and London are in the same latitude, but the former is colder than Lapland which is still further north. (3) South Italy and South Australia have similar climates. (4) Quito and Bogota, both under the equator, are very cold. Give reasons for these facts.

Q. 1256. How does the winter temperature of places on the west coast of the British Isles compare with that of the places in corresponding latitudes on the opposite side of the Atlantic ? Explain the difference. —Lon. Mat. 1902. Sep.

Q. 1257. (1) Siberia and Norway are in the same latitude but the former is much colder. Give three reasons for this. (2) Spain and Italy are in the Temperate Zone but they possess tropical climates. (3) The West Coast of the British Isles is warmer than the East Coast. (4) Kashmere enjoys the climate of Central Europe. Account for these facts.

Q. 1258. What causes the Gulf Stream ? Trace its course and state how it affects the climate of Western Europe.

—M. U. 1892.

Q. 1259. Explain the cause of excessive rain in the 'Doldrums.'

Q. 1260. Dense fogs are seen on the coast of Cape Colony as well as Newfoundland. The causes in both cases are similar. Explain fully what these are and their effect on navigation.

Q. 1261. Account for the high temperature in the south east of Cape Colony as compared with that of the west-coast.

Q. 1262. Explain why the Malabar coast is wetter than the Carnatic and (2) why Bangalore is cooler than Madras.

—M. U. 1904.

Q. 1263. What is called the "snow-line"? How does it vary in different latitudes? Quito, though under the equator enjoys the temperature of an English spring. How do you account for this ?

Q. 1264. Peru has almost no rain ; while the Western Coast of India has greater rain than the Eastern. How would you explain these facts ?

Q. 1265. What are the causes of rain in the following places ? (1) Ireland, (2) more rain on the West Coast of England than on the East Coast, (3) Guiana and Brazil.

Q. 1266. Take some one region of exceptionally dense population and show how it is related to physical features, climate, natural resources, and communications.—Lon. Mat. 1902 Sep.

Q. 1267. Give two reasons to account for the luxuriance of vegetation in the Amazon Valley. —M. Mat. 1901.R.

Q. 1268. What circumstances do you take into consideration if you are to ascertain the fauna and flora of a country ?

Q. 1269. What animals in the new world correspond to the following in the old? Lion, tiger, camel, ostrich, eagle, wild ox ?

Q. 1270. State and explain the barriers to the migration of animals.

Q. 1271. In what parts of the world are the following found ? Sloth, elephant, tapir, seal, zebra, mangoes, wheat, kangaroo and ostrich ?

Q. 1272. On the Himalayas are produced the various kinds of vegetation found in all the plant Zones. Explain this fact with reference to the flora of the Himalayas.

Q. 1273. Eucalyptus was unknown to India formerly, but it grows in that country at the present time. How do you account for this ?

Q. 1274. State all the facts you would take into consideration to determine the exports and imports of a country. Illustrate your answer.

Q. 1275. Explain the following terms :—Axis of rotation, Bore, Earth's orbit, Solar system, Snow-line, Neap Tides.
—Pun. Ent. 1903.

Q. 1276. How would you find the difference of time between Calcutta and Bombay ? —All. U. 1902.

Q. 1277. Define, continent, volcano, estuary, latitude, zones, oasis. —Cal. Ent. 1901.

Q. 1278. Give instances to show how far the commercial position of a country depends on its productions, geographical position, climate, contour (coastal line), and relief. —Lon. Mat. 03. Sep.

Q. 1279. How are waterfalls formed ? Describe three Indian waterfalls that you know of.—Pun. Ent 1904.

Q. 1280. At what period of the year would you expect to experience the greatest, and what period the least, amount of rainfall at Calcutta ? Give reasons.—Lon. Mat. 02 Sep.

Q. 1281. What are the following :—The Tundras, Trade Winds, Selvas, Sahara, the Maelstrom and the Runn.—M. U. 1882.

Q. 1282. Account for the following :—(1) The tropics are hotter than the temperate Zones : (2) Summer is warmer than winter : (3) the air is hotter at noon than at other times of the day.

Q. 1283. When should a signaller wire from London to Melbourne 145° E. and Quebec 70° W. so that the messages may be received in both the places at 6 a.m., the period of transit to each place being only 30 seconds ? —Pun. Ent. 1904.

Q. 1284. Compare the situation and configuration of western Europe and eastern Asia. Account for the differences in the climate, production, and trade of the two areas.
—Lon. Mat. 1903. Sep.

Q. 1285. Why is the Volga commercially less important than the Elbe ? —M. Mat. 1901. R.

Q. 1286. Define Physical Geography. Describe the formation of clouds, fog, rain, snow, and dew. —Pun. Ent. 1901.

Q. 1287. Explain the following terms :—Archipelago, watershed, bore, and selvas. —M. U. 1885.

Q. 1288. Explain the following terms with an example of each:—Estuary, water-parting delta, peninsula, ocean currents.

—All. U. 1902.

Q. 1289. Account for the following :—(1) The snow-line is not the same in all places, (2) in the tropics the *amount* of rainfall in the year is greatest but the number of rainy days in the year is fewest, (3) the sea is not full in spite of all the rivers that flow into it.

Q. 1290. Explain the following terms :—Meteor, fossil, bore, lagoon, solar system.—Pun. Ent. 1902.

Q. 1291. Explain how icebergs are formed and how they disappear. State their importance. State how it has been proved that glaciers slowly move on.

Q. 1292. (1) Why are the rivers of Southern India less suitable for navigation than the rivers of Northern India ?

(2) What is the chief drawback to the navigation of the Hugli ?

(3) Why do steamers from Madras to London go round the south of Ceylon ?

(4) What natural advantages for inland navigation are possessed by the Malabar Coast ?

(5) Why do the harbours on the east coast of India tend to silt up ? —M. U. 1903

Q. 1293. Why is it that there is an interval of six monthsin the corresponding seasons of the Northern and Southern Hemispheres.

Q. 1294. Explain three of the chief modes of projecting maps of large areas of the earth's surface and indicate the special advantages and disadvantages of each mode. —Lon. Mat. 1904 Jan.

Q. 1295. Define the following terms :—Archipelago, pampas, cataract, watershed, tributary, typhoon, sirocco, plateau.

—M. U. 1886.

Q. 1296 Give three examples to show that the rotation of the earth brings about a change of direction in moving masses of air and water.

Q. 1297. "The animal life as well as Nature generally ha been affected and influenced by man". Explain this with referenc to examples.

Q. 1298. Write a brief description, physical and political, o the Mediterranean sea. Indicate its most important strategic point and discuss the distribution of these among the European nations —Lon. Mat. 1904.

Q. 1299. What is meant by the following terms :—Meridians tundras, steppes, watershed. bright, north pole, left bank of river. —M. Mat. 1894.

Q. 1300. "Climate and other external conditions have a important effect upon the national character". Explain this wit reference to two well-chosen examples.

Q. 1301. What is meant by local time ? Show how a travelle gains or loses a day in going round the world.—Bom. U. 1902.

Q. 1302. Explain clearly when the telegrams despatched fro Madras at 6 a.m. on the 25th of June reach (1) London O° 5'W (2) New York, 74° W., (3) Melbourne 144°57' E. and (4) Pek 116°30E.

Q. 1303. Write short notes on the following :—(1) The Dea Sea ; (2) Sargossa Sea ; (3) Niagara Falls; (4) Great Barrier Ree (5) Adam's Bridge ; (5) Trade Winds ; (7) Rann of Cutch ; (8) Th Gulf Stream ; (9) The Sahara ; (10) Tundras ; (11) Banks of Ne foundland ; (12) Azores. —M. Mat. 1899.

Q. 1304. Some animals and trees are peculiar to certain par of the earth only. Explain the cause of this and state the cas where they have been introduced into countries which did n possess them before.

Q. 1305. (*a*) The southern side of the European Alps is w mer than the northern ; the northern side of the Australian Alps warmer than the southern. Account for these facts.

(*b*) The most popular settlements of Australia to the south and east. What are the physical facts that accou for this ?

(*c*) The rearing of sheep and cattle is the m important agricultural industry of Cape Colony. Show how is determined by the climate and nature of the country.

—M. Mat. 1904

Q. 1306. Assuming New York to be about long. 75°W and Berlin about 15° E. of Greenwich, and that time reckoned at both these places as if they lay *exactly* on these meridians, state what o'clock would it be at each when it is noon at Greenwich. Explain your answer.—Lon. Mat. 1902. Sep.

Q. 1307. What advantages does England derive from her geographical position.—M. Mat 1894.

Q. 1308. Enumerate the main constituents of the atmosphere and point out the connection of each with the vegetable and animal life on the globe. —B. U. 1902.

Q. 1309. Explain 'Thermal Springs,' 'Intermittent Springs,' 'Artesian Wells' and 'Affluents.'

Q. 1310. (*a*) North-east monsoon is a "dry monsoon," but Madras has rain in that monsoon. How is this explained?

(*b*) Ceylon has two rainy seasons. Explain how this is brought about.

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